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ABSTRACT

The report presents summaries of 11 studies performed on 25-45 autistic students in a residential center to investigate processes of discrimination and response acquisition using automated reinforcement technology and exact timing procedures. The computer operated display and recording system for language and discrimination training is described and diagramed. Eleven studies using the system are then presented, with information and analysis of the following topics: (1) consistency among commonly used procedures for assessment of abnormal children; (2) classification of abnormal children: discrimination learning ability; (3) sustained responding under intermittent reinforcement in psychotic children; (4) autoshaping of abnormal children; (5) relationships among two experimental and four psychometric assessments; (6) the relationship between rate of rhythmicity and stereotypic behaviors. (7) intrinsic and extrinsic reinforcement value and sign formations as factors in the the sign language training of autistic children; (8) preattention and attention in developmentally delayed children; (9) oddity performance and the perception of relational information; (10) the effect of contingent vs. non-contingent presentation of rhythmic asynchronous stimulation on the stereotyped behavior of children with autism; (11) an automated research and training system for child-clinical populations. (CL)

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SENSORY DISCRIMINATION, GENERALIZATION AND LANGUAGE TRAINING OF AUTISTIC CHILDREN

by

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Sensory Discrimination, Generalization and Language Training of Autistic Children

History of the Project

The project was funded on October 1, 1976 after a delay of several months. The project had been proposed to take advantage of a residential population of psychotic children, most of them with autistic features, at Walden House, a training center located proximal to the Vanderbilt-Peabody Campus area. The population of the center ranged from 25 to 45, and about 75% of the children were fairly constant residents. The Walden House Program was basically a behavioral one, involving one-on-one behavioral shaping methods and was regarded by parents and community as very effective.

Our proposal was to install an experimental laboratory, with computer controlled display and recording equipment to obtain exact data on the processes of discrimination and response acquisition using automated reinforcement technology and exact timing procedures. We proposed to employ stimulus fading, fractionation and delay procedures as described by Schreibman (1975) and others to shape perceptual discrimination and symbolic responses and establish appropriate responding. The following studies were proposed.

Classification procedures. Due to a four month delay in funding and consequent staffing problems, the project did not actually begin to collect data until January of 1977. At that time, the task of evaluating the population of children began. We felt it necessary to establish pre-experimental profiles of the children in order to determine whether the movement of the child through our sequence of procedures could be predicted. We tested the children with a comprehensive battery, obtaining Mental Ages and Intelligence Quotients as measured by either the Cattell or Stanford-Binet (depending on the child's level of functioning) and Social Quotients, as measured by the Vineland Social Maturity Scale.

Because establishing language skills was an important goal of the project, pre-experimental language level was assessed by staff ratings based on experience with the child's behaviors in the Center's program. Language function was categorized in the following way: (1) No Receptive and No Expressive, (2) Partial Receptive and No Expressive, (3) Receptive and No Expressive, (4) Receptive and Partial Expressive, (5) Receptive and Expressive, and (6) Normal Communicative Speech. The latter category had no entries form the psychotic population, but was included to permit better comparisons with control groups.

Data on a number of other variables related to case history were also obtained, including the Rimland Scales, which were sent to the parents of the children for completion. One of our goals was to assess the utility of these scales in identifying populations of psychotic children for participation in educational programs.

Development of the laboratory. During the spring months of 1978, we completed the fabrication and installation of our stimulus display system and installed a set of partitions, sound treatment and a one-way observation mirror on the third floor of the Walden House School. Since the building had been a large turn-of-the century residence, the utilities, especially the electrical current, presented problems due to fluctuations. Our intention had been to operate our displays on-line with our Hewlett-Packard 2114 computer, using an ASR 33 Teletype as a control device. Engineering studies showed this plan not to be feasible, and a contract was entered into with Tennessee Nuclear Corporation, a local independent engineering firm for a floppy-disc operated microprocessor system with both timed and latched input and output gates for the presentation and timing of stimuli and automatic administration of reinforcements. The apparatus and laboratory are described more fully below.

Self-stimulation studies. Meanwhile, Sharon Chilcote-Doner, a second year graduate student and research assistant on the project began a series of studies of stereotyped behavior, called "self-stimulatory" by behavioral workers. The first children were studied in a sound-proofed room at the Department of Psychology in Wesley Hall. The stimuli were stroboscopic lights and rhythmic music. Several of the children showed increases in stereotyped behavior under these treatments, and Ms. Doner designed a study for her doctoral dissertation, which was carried out in 1978-79 and is summarized below. Other workers on the project carried out a study of the relationship between rate of rhythmicity and stereotyped behavior, noted in the bibliography of studies already published.

Reinforcement value and sign formation in sign language training. Based on his earlier work on the language training of deaf children, a project on sign language training of autistic children was carried out by Dr. Blanton and Ms. Barbara Spalding in 1978.

Discrimination learning ability, autoshaping, and tolerance for intermittent reinforcement. Data for these studies, which had been proposed as central to the project, were collected in 1977, 1978, and in the spring of 1979. Dr. Terry Allen left the project in 1978, to be replaced by Dr. Stephen Maisto as a Research Associate. In 1979, Dr. Blanton was granted a sabbatical leave to study at the University of London. During the summer of 1979, as he was preparing to go, it became clear that Walden House was in serious financial difficulties, and would have to close. Storage space for the laboratory equipment was obtained at the Kennedy Center, and plans for installing the laboratory in proximity to the experimental school were drawn up. Dr. Albert Baumeister was very supportive in this relocation process, as was Dr. Carl Haywood.

During a storage period of about six months, the microprocessor developed serious hardware problems, which required an additional six months of engineering work to find and correct. Meanwhile, plans were developed and work begun to operate the display and reinforcement equipment manually, using a research assistant to control timing and recording operations. Extensive data analysis was carried out on data previously collected, and several articles were prepared for publication.

By the spring of 1980, the laboratory was again in partial operation. Unfortunately, however, the population of autistic children with which the project had begun had been dispersed, and with few exceptions were no longer available to us. With the consent of the agency, we began a series of experiments using mildly retarded and developmentally delayed children in the experimental school. There were, however, ample bodies of data from the work at Walden House to analyze. The following studies have been published based on that work and the subsequent work at the Kennedy Center Experimental School with the assistance of Dr. Salvatore Soraci who had replaced Dr. Stephen Maisto resulted in two studies, Oddity learning and the perception of relational information (already published) and Preattention and Attention (now under editorial review).

The bibliography of work published and unpublished from the project is as follows:

Deckner, C. W., Wilcoxon, L. M., Maisto, S. A., & Blanton, R. L. Autoshaping of abnormal children. Journal of Abnormal Child Psychology, 1980, 8(3), 339-350.

Deckner, C. W., & Blanton, R. L. (1980). Classification of abnormal children: Discrimination learning ability. *Journal of Autism and Developmental Disorders*, *10*, 405-415.

Deckner, C. W., Soraci, S., Deckner, P. O., & Blanton, R. L. (1981). Consistency among procedures commonly used for the assessment of abnormal children. *Journal of Clinical Psychology*, *37*, 856-862.

Deckner, C. W., Deckner, P. O., & Blanton, R. L. (1982). Sustained responding under intermittent reinforcement in psychotic children. *Journal of Abnormal Child Psychology*, *10*(2), 203-212.

Deckner, C. W., Soraci, S. A., Blanton, R. L., & Tapp, J. T. (1983-84). An automated research and training system for child-clinical populations. *Journal of Educational Technology*, *12*(3).

Deckner, C. W., Soraci, S., Deckner, P. O., & Blanton, R. L. (1982). The Rimland E-2 assessment of autism: Its relationship with other measures. *Exceptional Children*, *49*(2), 180-182.

Deckner, C. W., Blanton, R. L., Deckner, P. O., & Soraci, S. (1982). Assessment of specific behavioral deficits. *Exceptional Children*, *48*(5), 453-454.

Soraci, S., Deckner, C. W., McDaniel, C., & Blanton, R. L. (1982). The relationship between rate of rhythmicity and the sterotyped behaviors of abnormal children. *Journal of Music Therapy*, XIX(1), 2-27.

Soraci, S., Alpher, V., Deckner, C. W., & Blanton, R. L. (1983). Oddity performance and the perception of relational information. *Psychologia*, *26*(3), 175-184.

Deckner, C. W., Soraci, S., Blanton, R. L., & Tapp, J. T. (1984). An automated research and training system for child-clinical populations. *Journal of Educational Technology*, *12*(3), 233-238.

Deckner, C. W., Soraci, S., Deckner, P. O., & Blanton, R. L. (1984). Relationships among two behavioral and four psychometric assessments of abnormal children. *Journal of Clinical Child Psychology*, *13*(2).

Deckner, C. W., Soraci, S., Murata-Soraci, K., Weaver, T. L., & Blanton, R. L. (1984). Preattention and attention in developmentally delayed children. (under review)

Chilcote-Doner, S., & Blanton, R. L. The effect of contingent vs. non-contingent presentation of rhythmic synchronous stimulation on the stereotyped behavior of autistic children. (Ph.D. Dissertation)

The following studies have not been published:

Blanton, R. L., Deckner, C. W., & Erickson, J. (1979). A computer operated display and recording system for language and discrimination training.

Blanton, R. L., & Spalding, B. Intrinsic and extrinsic reinforcement value and sign formations as factors in the sign language training of autistic children. (Honors Thesis)

A Computer Operated Display and Recording System for Language and Discrimination Training

When the literature concerned with training various populations of handicapped children is reviewed, a practical problem becomes evident. Most of the procedures designed to accelerate learning, for example, in autistic, schizophrenic, and retarded children, require implementation through a one-to-one trainer-child ratio (Lovaas, 1977; Lovaas, Schreibam, and Koegel, 1974). Very few research studies or training programs have focused on the development of habilitative or remedial interventions that are implemented with marketable software programs or automated apparatus. This is particularly true in the important area of language training in which most of the research has been concerned with the acceleration of imitative speech with individualized shaping procedures (Lovaas, 1966). Most educational and treatment facilities lack the funds for a sufficient number of behavior modification teachers, primarily because of the low child-to-teacher ratios required by existing remedial procedures. Furthermore, such facilities do not have the resources for adequate in-service staff training. Automated equipment and procedures that would permit training of psychotic and retarded children by minimally trained personnel would therefore be highly desirable.

Additionally, it must be noted that a substantial number of children make little progress with the costly one-to-one training procedures that are currently in use. For example, many children either fail to learn to vocalize in imitation training, or the vocalizations do not become functional. Oftern failure to acquire a discrimination or to achieve a learning set can be attributed to the subject responding exclusively to a particular trainer. In this regard, subjects have been observed to perform for some trainers and not others, a problem that consumes time in identifying factors responsible for stimulus control. Moreover, it has been suggested that autistic and schizophrenic children respond more effectively in nonpersonal than in personal contexts (Davids, 1974). Further, a pragmatic consideration in favor of automated procedures is that the training necessary for low-functioning children is exceedingly repetitious and monotonous. This frequently results in a serious degree of trainer variability and error during extended sessions when manual procedures are used. Finally, "teaching machine" technology lends itself to optimization of a learning environment by permitting self-pacing, sequentially ordered tasks, small increments in task difficulty, and immediate reinforcement.

These considerations, particularly the potential savings in personnel time, could be expected to justify substantial initial costs in equipment development. In fact, however, there are so few systematic evaluations of the efficacy of teaching machines with psychotic children that it would be premature to generalize about their value. Although one recent study showed that a teaching machine alone was not as effective as a trained teacher, this study also showed that a machine used in conjunction with a teacher was an effective combination (Russo, Koegel, & Lovaas, 1978). Further, Russo et al. concluded that the factors contributing to the inferiority of the machine alone required elucidation. Establishing what these factors are, whether they are generally operative, and whether they can be obviated, are objectives of the present study.

Procedures and equipment used in our studies of psychotic children can be used in a wide variety of training applications, e.g., those requiring auditory, visual, and bimodal stimulus processing in such tasks as match-to-sample, sign tracking or autoshaping, and the acquisition of number and language concepts. Training procedures which require precise timing in stimulus presentation and termination--e.g., the errorless learning procedures, stimulus fading and stimulus delay--can be implemented with the system.

Design Considerations

The system is based on a Motorola 6800 microprocessor computer. Figure 1 is a block diagram of the system, and the details of the stimulus/reward system as shown in Figure 2. The microprocessor has 16,000 words of memory and uses a floppy disc system for storage of the operating system and the various experimental and training programs. Programming and entry of operating instructions are done by teletype. Response data and program

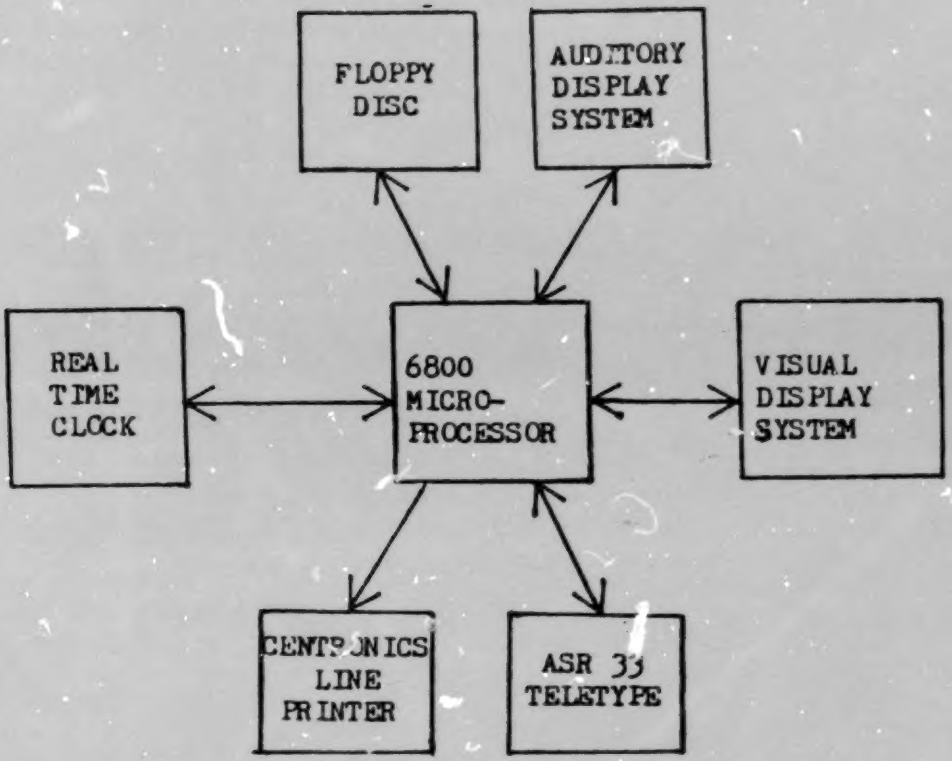

Figure 1. Block diagram of the computer operated system.

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listings are produced on a 120 character-per-second printer. The disc-based operating system, produced by Southwest Technical, Inc., provides access to an assembly language assembler, a BASIC interpreter, and a version of compiled BASIC. In our system currently, all software, with the exception of a short real-time clock routine, is implemented using the BASIC interpreter. Although assembly language programming usually would be used to control the real-time operation of a system such as this, the slower BASIC interpreter provides sufficient accuracy and allows programming by a wider group of investigators. As will be seen below in the discussion of the stimulus/reward subsystem, there are a large number of possible configurations of operations. Furthermore, the use of the BASIC interpreter permits easy modification of the operational software, thus allowing tailoring of programs to individual subjects.

The stimulus/response system consists of three 12 inch by 18 inch (30.48 by 45.72 cm) translucent panels which may be illuminated individually either by lights or by slide projectors. The slide projects are Kodak Ektagraphics, Model AF-2. Solenoid actuated flap-type shutters operate independently so that slides can be exposed for exact times and preclude exposure during the slide changing process. Each of the panels is constructed so that a small amount of pressure anywhere on its surface actuates a microswitch. Additionally, each panel is associated with a speaker that may be operated under computer control to provide simple tones, music or spoken words. The computer also controls a DSI Model 310 reward dispenser that drops food reinforcers into a tray below the center panel.

The computer operates the system through a pair of registers (Figure 2) that are used to issue commands to the various devices and to determine the status of the panel switches and the projector operations. Each function of each of the system's devices, e.g., projector forward, projector reverse, has a command number assigned to it. The execution of a function is evoked by the computer by loading the appropriate number in the command register. Only one operation can be evoked at a time but the interval between successive requests is not discernable to an observer.

The status register is used to monitor the subject's response by indicating to the computer that one or more of the panel switches has been closed. It is also used to ensure that a projector has responded to a command to move. Each bit of the eight-bit status register is assigned to one of the devices being monitored so that the status of all of them can be determined with a single computer command. When a subject presses a panel, a corresponding bit in the status register is set to one. By examining the register, the computer can tell whether and which panel has been pressed.

The real-time clock is used to time trial durations, training sessions, and the subject's response latencies. The clock operates at a base frequency of 10 ticks per second and consists of two separate counters. One of the counters determines total elapsed time. It is cleared at the beginning of a run and counts clock ticks oncinuously throughout the run to a maximum of 100 minutes. The second register is a stopwatch register that is used to time shorter intervals (maximum = 25.5 second) during a run. When used, this register is loaded with the desired number of clock ticks and allowed to count down to zero.

Each of the devices in the system can be operated independently. With the devices under computer control, each can be operated at any time or in any manner that the investigator requires. The only limitations are mechanical restrictions such as the time required to advance the slide projectors or to life the shutters.

A Discrimination Learning Sequence

In order to illustrate the versality of this system, one of the programs used for one of our experiments will be described. It must be emphasized that although a simpler, less expensive hardwired system could have been constructed to run the illustrated sequence, a hard-wired system would be limited to this sequence and would not allow other useful modes of operation. FIgure 3 is a block diagram of the sequence to be discussed.

In this example the subject is presented with two slides, one which is "correct" and one which is "incorrect" (section BI to CI). A predetermined trial interval (TI) is set during which the subject can respond by pressing the panel on which the slide

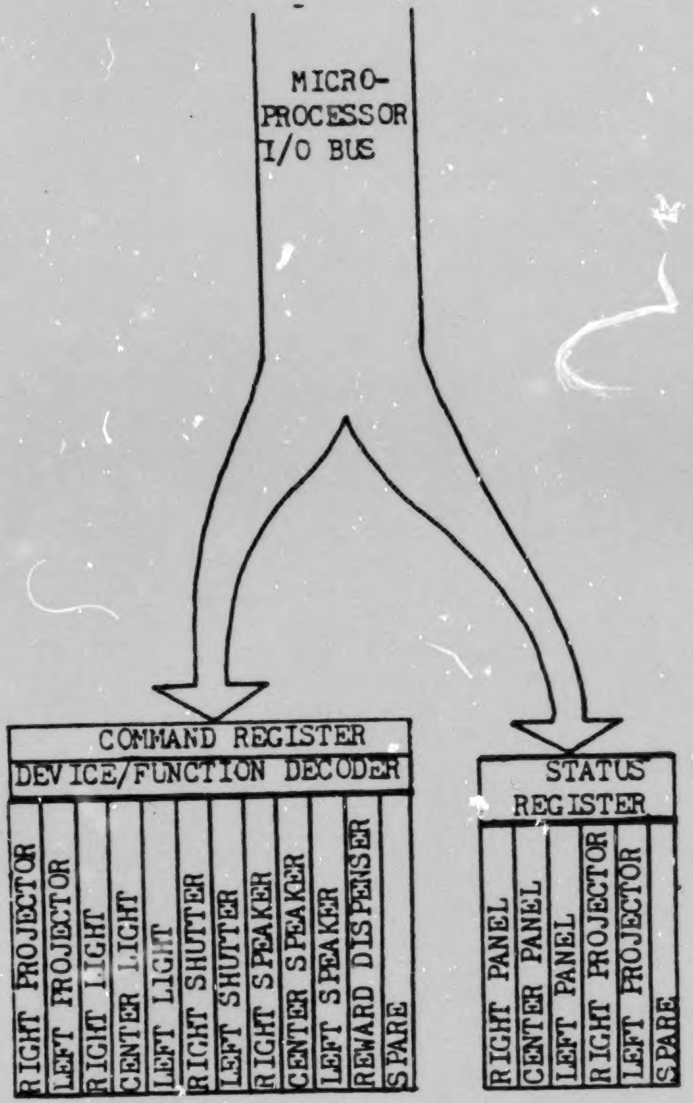

Figure 2. The stimulus/reward system.

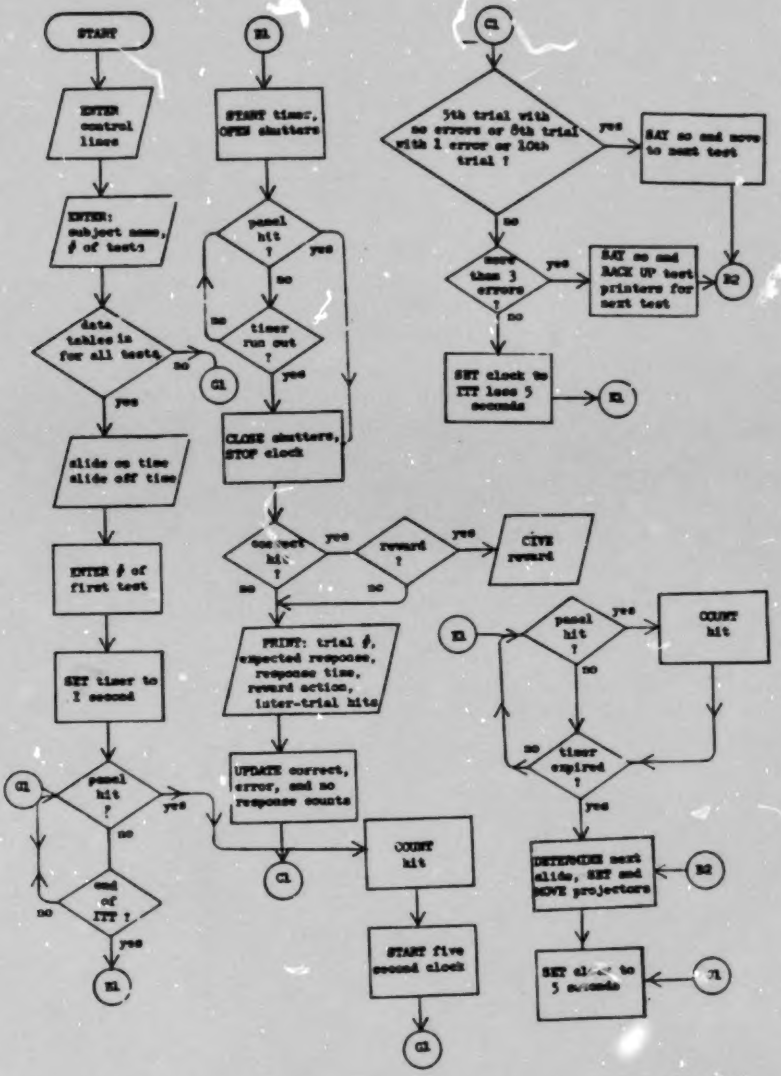
START
ENTER control lines
ENTER: subject name, # of tests
data tables in for all tests
no
C1
yes
slide on time slide off time
ENTER # of first test
SET timer to 1 second
G1
panel hit ?
yes
no
end of ITT ?
no
yes
E1
E1
START timer, OPEN shutters
panel hit ?
yes
no
timer run out ?
no
yes
CLOSE shutters, STOP clock
correct hit ?
yes
no
reward ?
yes
no
GIVE reward
PRINT: trial #, expected response, response time, reward action, inter-trial hits
UPDATE correct, error, and no response counts
C1
COUNT hit
START five second clock
G1
C1
5th trial with no errors or 8th trial with 1 error or 10th trial ?
yes
SAY so and move to next test
no
more than 3 errors ?
yes
SAY so and BACK UP test printers for next test
B2
no
SET clock to ITT less 5 seconds
H1
H1
panel hit ?
yes
COUNT hit
no
timer expired ?
no
yes
DETERMINE next slide, SET and MOVE projectors
B2
SET clock to 5 seconds
J1

Figure 3. Block diagram of a discrimination learning sequence.

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of his/her choice is projected. When the subject responds, or in the case of no response, when the TI expires, the display is terminated. If the choice is "correct," the subject may or may not be rewarded as dictated by the experimental procedure being implemented. After the display is terminated, an inter-trial interval (ITI) is begun (sections CI to GI). During the ITI, the results of the previous trial are printed on the line printer and the slide projectors move to the positions for the next slide. The panels are monitored to determine the number of ITI panel presses. During the main body of the ITI, these presses are merely counted. However, if a response occurs during the last five seconds, a timer is tripped and slide presentation is postponed for five seconds after the last such response. Any panel press during the last five seconds of the ITI restarts the timer so that repetitive responding during this interval effectively postpones subsequent slide presentation indefinitely. This programmed "time out" (TO) from the opportunity to work for reward is to eliminate indiscriminant responses which otherwise might be maintained by the adventitious reinforcement through presentation of the slides. In this example, a five-second TO was considered sufficient to eliminate indiscriminant panel presses. However, all temporal parameters--e.g., the TI, ITI, and TO--can be set and flexibly modified by the investigator as he wishes.

In this example each test level of the discrimination task consists of 10 trials, i.e., 10 presentations of a pair of slides. If the subject does not make a choice during the TI, an option is to have the same slide pair re-presented until a response is made. Incorrect and correct choices are counted and used to determine the testing sequence (section CI). If at any time during a given test the subject makes a total of three errors, that test is terminated, the projectors are returned to the last level at which the subject was successful, and a new test is started. If the subject reaches the seventh trial with no errors, the eighth with no more than one error, or the tenth trial with no more than two errors, he is advanced to the next, more difficult, test level. This sequence continues until the investigator terminates the run (e.g., because stability or failure criteria have been reached) or until the subject progresses through the entire set of available tests.

The slide-presentation sequence and the reward protocol are entered by the experimenter into the system through a set of data tables. Each entry in a data table consists of one line of 10 slide-control words. Each control word specifies which slide is to be presented by the left and right projectors as well as which slide is "correct." A second line contains the reward controls, which consist of two five digit numbers. Each of these 10 digits corresponds to one of the 10 trials specified in the first control line. This method of control allows precise determination of the slide presentation sequence and specification of as many as 10 potentially reinforced responses for each test level. With the flexibility provided by the system, it is a simple matter to vary the schedule of reinforcement. For example, the children might be exposed to progressively leaner schedules of reinforcement in a manner that is sensitive to the individual child's rate of errors and/or nonresponding.

Auditory Cues That Can Be Used in Visual Discriminations

In the development of the auditory system, an effort was made to take advantage of some of the more advanced technology under development in the area of computer science. Thus, we initially proposed to convert words to digital form, store them on discs, and have them retrieved and converted to analogue form. After considerable experimentation and design difficulty, we concluded that this approach was not feasible at this time, although rapid progress is being made by the micro-circuits industry in the development of special chips for this purpose. Rather than wait for such components, we have developed a system of cassette recorders using continuous loop tapes, each of which contains 16 words. The computer selects, according to program, one or more of the words to correspond to a particular display, e.g., if a display consists of a spoon and a shoe, and the correct response is to press the panel showing the shoe, the computer selects the word "shoe" from the tape and presents it over a loudspeaker.

The auditory-display consists of three speakers, one located above each of the three visual display panels. The spoken word may be presented over any of the three speakers, depending upon the nature of the task, e.g., it may be presented as a prompt on the speaker corresponding to the slide it designates and thereby provide a position cue. The auditory prompt may then be gradually faded to the center speaker and thereby require attention to the auditory cues' specific acoustic properties (e.g., "spoon" as distinguished from "shoe"). Any combination of the three speakers can be used. Three, gain-programable amplifiers are used with 256 settings, each of which can be selected by the program; this permits the fading up or down of any or all speakers over trials. The computer can be programmed to have the fading of auditory and visual cues progress in a manner that is sensitive to the accuracy of the child's response. Six-timed, relay-output ports and eight latched, relay-output ports permit the addition of other computer controlled equipment to the auditory system.

In conslusion, many practical and theoretical problems remain to be studied regarding the implementation and utility of systems of the type described. Among these are questions of display size and configuration, temporal interval selection for various tasks, and improved procedures for task-error reduction. Also, the presence or absence of personnal in the room with the child (i.e., remote operation), the use of social reinforcers, prompts and punishers dispensed by the auditory system (i.e., praise, urging, admonishing, etc.), and the use of self-pacing techniques all remain to be evaluated.

A series of studies using the system is described below. Considering the steadily diminishing costs of computer equipment, we believe that the future may lie with general purpose systems and software controlled experimental procedures rather than with hard-wired equipment. The system presented here has some of the features and corresponding advantages of the type of system that we anticipate will be increasingly utilized with learning-disabled populations in the future.

At the end of this report, we include a report on a more advanced system now in use at the Kennedy Center. That report has been published, as indicated in the introductory bibliography.

Consistency Among Commonly Used Procedures for Assessment of Abnormal Children

Insufficient information exists concerning the interrelationships among assessment procedures widely used with abnormal children (Isser, Quay and Love, 1980). As an example, the E-2 Scale (Rimland, 1971), which is frequently employed to assess the extent to which a child approximates Kanner's syndrome, classical autism, has not been correlated with any established psychometric test (Note 1). Rimland (1971) and Kanner (1958a; 1958b) have argued that it is crucial from the standpoint of etiology and treatment to differentiate autistic children not only from mentally retarded children but also from other types of psychotic children. Controversial findings that may imply that autism is a unique clinical entity have been reported with respect to the E-2's correlation with biochemical variables (cf. Boullin, Coleman, O'Brien and Rimland, 1971; Rimland, 1976). Other investigators have not replicated these findings, however, and, more pertinantly, the E-2's relationship to psychometric variables that are generally regarded to be important diagnostically aand prognostically has not been examined.

More research has been done to ascertain psychometric interrelationship in retarded populations than in psychotic populations. A representative study with retarded children is that of Erickson, Johnson, and Campbell (1970), who report the correlations among the Bayley Scale of Mental Development (Bayley, 1969), the Cattell Infant Intelligence Scale (Cattell, 1940), and the Vineland Social Maturity Scale (Doll, 1953). Erickson et al. (1970) concluded that the two intelligence tests correlated so highly that they could be considered interchangeable. Although significantly correlated with the two intelligence tests, the Vineland yielded higher scores. It is a testable question whether the same relationships among variables found with retarded children would also be found with psychotic children. Regarding biochemical and psychometric variables, the study by Boullin et al. (1971) suggests that the relationships are not the same.

The present study was designed to extend the findings of Erickson et al. Although there are other studies that have examined the relationship of intelligence tests and the Vineland in retarded populations (Leland, Shelhaas, Nihira and Foster, 1967), the Erickson et al. study is representative, and it is regarded as a useful point of reference.

Erickson et al. studied 30 preschool children who ranged in age from 6 months to 6.5 years with a mean age of 32.6 months. Their description indicates that the children were no more than mildly behaviorally disordered. To provide information regarding generality across populations, the following differences obtained between the present study and that of Erickson et al.: Substantially older children (a mean age of 9.42 years) were studied; the majority of the children were severely behaviorally disordered; and most of the children had been given various diagnoses of psychosis. In addition to replicating Erickson et al.'s use of the Vineland and the Cattell, the Stanford-Binet was used and all children were assessed with a scale of language development. Finally, a subgroup of the children was assessed with th E-2 Scale.

Method

Subjects

The subjects were 7 girls and 15 boys in a school for psychotic children. The policy of the school was to serve autistic, autistic-like, and schizophrenic children as distinguished from mentally retarded children. Most of the children in the school were severely behaviorally disordered and difficult to control, and all were developmentally retarded. They evidenced few or no appropriate self-help skills, and none approached normal language functioning. Most of the children were admitted to the school after habilitative efforts in other agencies had been unsuccessful.

The last consideration is relevant to the representativeness of the sample (i.e., they were not merely the children of a single school) and also reflects the severe extent to which the children were behaviorally disordered. Kanner (1958a) and Rimland (1976) assert that only about 10% of psychotic children labeled autistic are in fact autistic. Assuming their stringent criteria, we had no expectations that this group would be different despite the school's policy. However, it is reasonable to say that the children were not simply retarded. Most of them were psychotic in the sence of exhibiting bizarre behaviors, and most of them had received various diagnoses of psychosis from other agencies before coming to the school. For detailed descriptions of the behavior of typical children in the school and a sample of the diagnoses given the childred, see Deckner, Wilcox, Maisto and Blanton (1980).

Psychometric Variables

MAs and IQs were obtained with either the Stanford-Binet (Form L-M) and/or the Cattell Infant Intelligence Scale, which was designed to be a downward extension of the Stanford-Binet (Erickson et al., 1970), depending on the individual child's level of functioning. Husted, Wallen, and Wooden (1971) report that tangible reinforcers can be used in testing to increase attentiveness, motivation, and consistency of response, and thereby give a more accurate assessment of the intelligence of profoundly retarded children. Hence, the children were intermittently reinforced with small bits of preferred foods for remaining seated and for attending to the tester. Reflective of the extent to which the children were behaviorally disordered, it would have been impossible to complete the evaluations of many of the children without reinforcing general compliance in this way.

Leland et al. (1967) assert that adaptive behavior is an important classification dimension that should be used in conjunction with classification based on intellectual functioning, and the Vineland Social Maturity Scale is a widely used assessment of adaptive behavior. Vineland social ages (SA) and Vineland social quotients (SQ) were obtained from interviews of trainers who worked regularly with the children.

Language functioning, even though rudimentary, has been reported to be important prognostically by various researchers (e.g., Lovass, 1977). The language functioning (LF) of the children was rated according to the following to the following 5-point scale.

1. No recepetive and not excpressive vocabulary.
2. Partial receptive and no expressive vocabulary.
3. Receptive and no expressive vocabulary.
4. Receptive and partial expressive vocabulary.
5. Receptive and expressive vocabulary.

The children were rated with regard to LF by the Clinical Director of the school, who was familiar with all of the children in the institution. His ratings were made prior to administration of the intelligence tests, the Vineland and the E-2. However, since this language measure is not commonly used as are the other measures, less importance is attahced to it.

Finally, the children's parents who could be located were mailed copies of the E-2 with as cover letter requesting completion of the retrospective checklist. A follow-up mailing was made to parents who did not respond to the initial mailing. It was possible finally to obtain completed E-2 Forms from parents of 17 of the 22 children.

Results

Section A of Table 1 presents means, standard deviations and ranges of the 22 children with respect to IQ, MA, SQ, SA, LF and chronological age (CA). Section B of this table shows the intercorrelation matric of these six variables. The Pearson product-moment correlation coefficients were generally high, indicating strong relationnships among the variables. An exception was the CA correlated only with MA.

TABLE 1

(A)
Means, Standard Deviations (SD), and Ranges of Six Individual-Difference Variables for 22 Subjects

Variable	Mean	SD	Range
MA	23.32	9.98	7-42[a]
IQ	20.41	9.13	8-47
SA	35.41	20.56	16-90[b]
SQ	31.36	14.61	12-62
LF	3.05	1.64	1-5
CA	9.45	2.77	5.25-16.92[c]

(B)
Correlation Matrix for the Indicated Variables

Variable	MA	IQ	SA	LF	CA	
MA	-					
IQ	.72***	-				
SA	.80***	.51*	-			
SQ	.69***	.80***	.84***	-		
LF	.87***	.64**	.81***	.72***	-	
CA	.44*	-.21	.37	-.11	.40	-

a, b, c: CA is in years: MA and SA are in months.

* $p < .05$
** $p < .01$
*** $p < .001$

Table 2 has a similar format to Table 1. It includes the six variables of Table 1 plus measures based on the E-2. Scoring of E-2 Forms is carried out at Rimland's Institute for Child Behavior Research where the test is broken down into its two components, behavior and speech. Designed to be a quantitative estimate of the presence of features of autism, the E-2 may yield negative speech and/or behavior scores because the number of non-autistic signs is subtracted from the number of autistic signs. To avoid the problem negative numbers pose in computing correlations, a constant of 25 was added to each child's behavior score and also to each child's speech score.

It may be seen that the speech component correlated with each of the psychometric assessments of ability and the total score did so with all but IQ. However, the behavior component correlated only with LF. Perhaps most noteworthy is that the two components of the E-2 have a relatively low inter-correlation. In this sample, the behavior and speech components correlated only .35.

TABLE 2

(A)
Means, Standard Deviations (SD), and Ranges of Psychometric Variables for Children with Rimland Scale Scores (N = 17)

Variable	Mean	SD	Range
MA	23.11	9.65	7-38[a]
IQ	19.72	9.01	8-39
SA	36.24	19.28	16-78[b]
SQ	30.29	13.41	12-58
LF	2.88	1.57	1-5
CA	9.42	1.96	5.30-13.08[c]
Rimland Behavior	25.53	12.26	3-48
Rimland Speech	27.00	4.00	21-37
Rimland Total	51.94	13.98	30-82

(B)
Correlation Matrix of the Indicated Variables

							Rimland		
Variable	MA	IQ	SA	SQ	LF	CA	Behavior	Speech	Total
Rimland Behavior	.44	.39	.44	.34	.55**	.30	-		
Rimland Speech	.70***	.50*	.69***	.67***	.68***	.21	.35	-	
Rimland Total	.52*	.44	.61***	.52*	.66***	[illegible]7	.95***	.58***	-

a, b, c: CA is in years: MA and SA are in months.

* p < .05
** p < .02
*** p < .01

Discussion

Nunnally (1978) speaks of the accumulation of evidence that leads to the validation of constructs as fundamental to the development of all sciences. The present results constitute further evidence for inferring the construct validity of the assessments of intelligence and social competence even though the results were obtained with an extremely abnormal population. The present findings also suggest the construct validity of the ratings scale of language functioning. The construct on which these assessments converge can be termed general psychosocial development. With good consistency, children who were assessed to be either relatively high- or relatively low-functioning by one measure were also so assessed by the other measures.

Suggesting generality across populations, the present results were consistent with those of Erickson et al. even though the present subjects were much older (a mean age of 113.44 months as compared to 32.6 months), had substantially lower IQs (a mean of 20.41 as compared to 48.20), and were more severely behaviorally disordered than those studied by Erickson et al. Further, the present subjects were regarded to be psychotic rather than mentally retarded. Erickson et al. report correlations between the Cattell and Vineland of .83 and between the Bayley and Vineland of .79. In the present study, it was sometimes necessary to use both the Cattell and the Binet with the same child in order to establish both a basal and a ceiling. The correlation obtained in the present study between the SQ and IQ, .80, is remarkably similar to those reported by Erickson et al. Even though neither the Erickson et al. study nor the present was based on a large sample (Ns of 30 and 22, respectively), the consistency between the two provides basis for confidence in the reliability of their findings. It may be suggested that two moderate size samples that yield highly consistent results are more convincing than results obtained with a single large sample (Nunnally, 1978).

These findings suggest that the choice of tests in an attempt to predict a child's future level of functioning may reasonably be made on the basis of practical, as distinguished from psychometric, considerations. Although recent advances have been made in methods of direct testing (Schopler and Reichler, 1971), the difficulties in administering intelligence tests to a significant portion of exceptional children are such that many workers in the field continue to be deterred from the attempt (for relevant discussion see Alpern, 1967; and Schopler and Reichler, 1971). The fact that the Vineland can be administered easily, since its format calls for obtaining information from an interview of adult observers, is therefore a noteworthy practical consideration. The present results, considered with those of Erickson et al., suggest that the Vineland may have predictive validity that is comparable to that of direct tests of intelligence.

The consideration that the Vineland focuses on current functioning while the E-2 focuses on circumstances at birth and on functioning during the first five years of life is also important from a practical standpoint. Locating and obtaining the cooperation of persons who have the extensivefamiliarity with a child's earliest history necessary to complete the E-2 is a significant problem. This problem may be particularly acute in studies of older children for whom habilitative efforts have been unsuccessful since their parents are less likely to be accessable, less likely to be motivated to complete the lengthy retrospective forms, and less likely to remember accurately the information that is requested. Cohen, Caparulo, Gold, Waldo, Shaywitz, Ruttenberg and Rimland (1978) indicate that even though the families of children whom they studies were accessable, they also encountered an unwillingness to complete the detailed questionnaire.

While the Vineland may be a useful assessment with children who are not amenable to direct intelligence testing, it must be noted it yielded higher scores than the direct tests of intelligence. In the present study, the SQ-IQ mean difference was 10.74. Erickson et al. found a SQ-IQ mean difference of 5 with respect to the Cattell and 8 with respect to the Bayley. Erickson et al. indicate that such discrepancies in scores are more likely to occur with children who manifest large disparities between mental and motor development: children with higher motor development than mental development tend to have higher Vineland scores than IQ scores; children who are physically handicapped typically show the opposite discrepancy. Consistent with this observation, the children of the present study, although manifesting profound cognitive deficits, were generally free of physical handicaps.

These discrepancies in scores indicate that we should differentiate the question of the predictive validity of the Vineland relative to that of the intelligence tests from the questionn of their respective uses in present placement of children into specific categories of developmental functioning, e.g., moderate retardation. There would be considerable error in the latter type of placement if the Vineland and the intelligence tests were used interchangeably. While this consideration must be borne in mind, we agree with Erickson et al. that the Vineland can be regarded as a useful screening test in detecting children with potentially abnormal development when the children are not amenable to direct testing. The present results, considered with those of Erickson et al., indicate that the Vineland has this utility whether the children in question are retarded o psychotic.

Although these are generally positive considerations, the correlations between IQ and SQ are in fact so high that only to a limited extent can these measures be regarded as distinct and different. The obtained correlation of .80 implies a 64% overlap of the variances of the measures of IQ and SQ. Stated otherwise, the measures are redundant except for 36% of their variances. Contrary to the assertion of Leland et al. (1967), it seems questionable whether adaptive behavior, at least as measured by the Vineland, can be regarded as a new dimension in classification. The language rating scale used here also had relatively little independent variance. These nominally different measures, therefore, provide relatively little unique information.

There may be advantages, therefore, in measures that focus on specific behavioral deficits as distinguished from those that assess global constructs such as intelligence and adaptive behavior in a general sense. One advantage may be that different measures with specific foci will in fact measure distinct and different dimensions. Another advantage may be that assessments of specific behavioral deficits are more likely to be prescriptive than global indicants such as an IQ scores (Bro[illegible] Baumeister, 1977). As an example, Deckner and Blanton (1980) describe an assessment task that has good face validity regarding deficits in discrimination learning ability. Although the task was found to correlate significantly with measures of intelligence, adaptive behavior and language functioning, it was less redundant with those measures than they were with one another.

Because the relationship of the E-2 with standard psychometric tests had not been reported previously, we felt that the E-2 Form's correlations with the psychometric variables considered in the present study were of interest. To the extent that the E-2 correlates with measures established to be of prognostic value (e.g., intelligence, Bartak, 1978; social competence, Doll, 1950; language functioning, Lovaas, 1977), it also could be expected to have prognostic significance. All of the children in the present study were markedly abnormal. The obtained correlations thus may suggest that those who are abnormal because they display features of autism tend to be higher functioning and to have better prognoses than children who are abnormal in a nonautistic sense.

While we previously noted that the E-2 was designed for a different purpose than the other assessments, there is a clear need for research that delineates its relationships with important variables. The present results are viewed as an initial step in establishing the E-2's place in the network of measurements pertinent to the study of exceptional children.

Perhaps the most provocative finding of the present study is the low intercorrelation of the two components of the E-2 (.35). If a low correlation between the speech and behavioral components is found with other samples of psychotic children, this would seem to be antithetical to unitary concepts of autism such as proposed by Kanner. If one accepts Kanner's thesis, it is paradoxical to conceive of children who are autistic in behavioral development and other children who manifest the opposite, uncorrelated pattern. Kanner hypothesized that the syndrome of autism is the manifestation of a single disease process, and Rimland continues to espouse this view.

This paradox is possibly resolved b[illegible]sideration of a recent comment by Schopler (1979) that is probably representative of the view of the majority of investigators in the field (Rutter, 1978). Schopler states that during the 30 years since Kanner advanced his hypothesis, no evidence has been found to substantiate it. "Instead, subsequent information has shown that multiple causal mechnisms are most likely capable of producing the syndrome" (p. 455). The obtained E-2 scores thus may be an accurate reflection of a sybstantial heterogeneity in the development of features of autism.

Classification of Abnormal Children: Discrimination Learning Ability*

The findings of an increasing number of investigators in the fields of psychopathology and mental retardation suggest that there are advantages in classification based upon specific behavioral deficits relative to traditional diagnosis (Strauss and Carpenter, 1972; Pope and Lipinski, 1978), and also relative to classification based upon global indicators such as an IQ score (Brooks and Baumeister, 1977).

The purpose of this paper is to describe a discrimination-learning task that can serve as a classification procedure when specific assessment of this important area of functioning is indicated. As an initial step in validating the experimental assessment, its correlations with psychometric variables generally regarded to be important prognostically are reported. The classification procedure can be implemented either with automated equipment, as reported in this paper, or manually.

Method

Subjects

The subjects were 15 boys and 6 girls. Most of the 21 children were severely behaviorally disordered, and all were developmentally retarded. They evidenced few or no appropriate self-help skills, and none approached normal language functioning. Most of the children were admitted to the school after previous habilitative efforts had been unsuccessful.

The latter consideration is relevant to the representativeness of the sample (i.e., they were not merely the children of a single school) and also reflects the severe extent to which the children were behaviorally disordered.

Psychometric Variables

MAs and IQs were obtained with either the Stanford-Binet (form L-M) and/or the Cattel Infant Intelligence Scale, which was designed to be a downward extention of the Stanford-Binet (Erickson, Johnson and Campbell, 1970), depending on the individual child's level of functioning. Husted, Wallen, and Wooden (1971) report that tangible reinforcers can be used in testing to increase attentiveness, motivation, and consistency of response, and thereby give a more accurate assessment of the intelligence of profoundly retarded children. Hence, the children were intermittently reinforced with small bits of preferred foods for remaining seated and for attending to the tester. Relevant to the extent to which the children were behaviorally disordered, it would have been impossible to complete the evaluations of many of the children without reinforcing general compliance in this way. Since such tangible reinforcers were also to be used in the classification task described below, this had the additional effect of providing consistency between the two assessment procedures.

Leland, Shelhaas, Nihira and Foster (1967) assert that adaptive behavior is an important classification dimension that should be used in conjunction with classification based on intellectual functioning, and the Vineland Social Maturity Scale is a widely used assessment of adaptive behavior. Thus, Vineland social ages (VA) and Vineland social quotients (VQ) were obtained from interviews of trainers who worked regularly with the children.

Finally, language functioning, even though rudimentary, has been reported to be important prognostically by various researchers (e.g., Lovaas, 1977). The language functioning (LF) of the children was rated according to the following 5-point scale:

1. No receptive and no expressive vocabulary.
2. Partial receptive and no expressive vocabulary.
3. Receptive and no expressive vocabulary.
4. Receptive and partial expressive vocabulary.
5. Receptive and expressive vocabulary.

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Prior to the administration of the intelligence tests, the Vineland and the experimental assessment procedure, the children were classified with regard to language functioning by the clinical director of the school who was familiar with all of the children in the institution. However, since this language measure was not standardized as are the other psychometric variables, less importance is attached to it.

Apparatus

The experimental apparatus was computer controlled and has been described in detail above.

All training took place in the laboratory room described above. The chair for the subject was placed directly in front of the food tray. Only the two side panels were operative in this study.

The Discrimination Learning Task

The numerosity continuum. The children were manually shaped to respond to a panel on which a pattern of 10 dots was projected. This was the S+ panel throughout training. Initially, the alternate, or S- panel, was lighted to be as bright as the S+ panel, but no dots were projected on it. The position of the S+ panel was determined randomly. The orientation of the patterns of dots was varied across test levels.

The children had 10 seconds to respond to the discriminative stimuli on each trial. The intertrial interval (ITI) was 15 seconds. The computer monitored the panels to determine the number of ITI panel presses. During the first 10 seconds of the ITI, these presses were merely counted. However, if a response was made during the last five seconds, slide presentation was postponed for five seconds after the last such response. Any panel press during the last five seconds of the ITI restarted a timer so that repetitive responding during this interval effectively postponed subsequent slide presentation indefinitely. This programmed time-out from the opportunity to work for reward was designed to eliminated indiscriminate responding that otherwise might be maintained by adventitious reinforcement through presentation of the slides.

The children were manually shaped according to the following procedures. First, the child was required to remain seated with his or her eyes oriented toward the panels. In order to promote appropriate behavior, the discriminative stimuli were not presented until the child was seated quietly and was attending to the panel. After presentation of the S+ and S- panels, the child's hand was placed on the correct panel, the panel was pressed, and reinforcement was presented immediately and automatically. After a number of such full prompts, the trainer gradually faced his prompting until the child worked independently. Reinforcement consisted of a variety of small edibles and a doorbell chime that was immediately contingent upon a correct responce.

The experimenter withdrew from the room when unassisted, correct responding occurred on 10 consecutive trials. The subject was then given 20 additional trials with the requirement of responding to the pattern of 10 dots versus an empty circle of equal brightness. If the subject responded correctly without assistance on a minimum of 80% of this block of 20 trails, he or she was advanced to the next level, which was 10 versus one. Eighty percent correct was the criterion for advancement throughout. Each time a child reached this criterion, he or she was advanced to the next level of difficulty, i.e., 10 versus two, 10 versus three . . ., 10 versus nine.

If at any point in a block of 20 trials a child made his or her fourth error, did not respond on four trials, or combined non-responding with errors for a total of four incorrect trials, the test was immediately terminated. On such occasions, the child was returned to the last level of difficulty at which he or she had been successful. Then the child was again given the opportunity to advance.

The children were run once a day, and a session was ended for a given day according to the following criteria: the child failed at the same test level on two consecutive attempts; the child failed at three consecutive test levels, even though following each failure he or she was taken to the preceding, easier test; the child failed to respond for two consecutive minutes; 20 minutes of running time had elapsed.

The brightness continuum. It was found that 16 of the children did not respond reliably to the pattern of 10 dots when the S- was an empty circle of equal brightness. Therefore, an opaque slide was presented as a new S-. If the child responded to a 10 versus the darkened panel, he or she was then presented with a series of eight progresively brighter S- slides. The final slide in the resulting nine-point brightness continuum was the empty circle that was as bright as the pattern of 10 dots.

Each test level consisted of 20 trials at a given level of brightness for the S-. The criteria used in the numerosity task for increasing and decreasing the difficulty of the discrimination, and for ending a session, also were used in this brightness fading procedure. If a child progressed through all nine test levels of the brightness continuum, he or she was again presented with the numerosity continuum.

Results

Five of the 21 children responsed effectively on the numerosity task and therefore were not given the brightness fading procedure. Three of these children progressed to the most difficult discrimination of 10 dots versus nine dots. These children achieved this discrimination within five to seven 20-minute sessions. With our present automated equipment, a child can be tested on approximately 90 trials during one 20 minute session. Two other children achieved discrimination levels of 10 versus six and 10 versus eight within 10 sessions. In this regard, a child was defined as having stabilized at his or her discrimination-learning threshold when he or she failed at a particular test level four consecutive times across two days.

With the introduction of the brightness fading procedure, 10 children eventually discriminated between 10 dots and the empty circle of equal brightness. These children did so within nine sessions: the number of trials required ranged from 90 to 430. Further, although one of these children could progress no further, the other nine were then able to progress into the numerosity continuum. One of the latter chidlren eventually succeeded at the most difficult discrimination of 10 versus nine. The other eight children succeeded at levels of discrimination varying from 10 versus one to 10 versus eight.

Despite exposure to the brightness fading procedure, six of the children never reliably responded to the 10 dots when it was contrasted to an empty circle of equal brightness. However, these children progressed to different points on the brightness continuum, and the procedure thereby enabled differentiation even among these very low-functioning children.

The Measure of Discrimination Learning Ability

Discriminative responding was measured by a Performance Index (PI), which was based on data from the last four days that a child participated in the study. In developing the PI, the nine-point brightness continuum and the nine-point numerosity continuum were assumed to constitute an 18-point discrimination-learning scale. The PI was designed to reflect attained level of task difficulty. In this regard, a weight of one was assigned to the easiest discrimination and a weight of 18 was assigned to the most difficult discrimination. The PI was also designed to reflect accuracy of performance. Hence, the number of correct responses at a given test level was multiplied by the weight assigned to that level. Finally, the PI was designed to reflect efficiency of progress through the discrimination-learning task, i.e., learning rate. Specifically, children who passed test levels on their first attempt and were never returned to those levels were regarded as having higher learning rates than children who (a) encountered the same test levels repeatedly, (b) had to progress through the brightness-discrimination continuum, and (c) encountered an inflated number of test levels because of a combination of both of these reasons. To reflect learning rate, the number of test levels encountered was divided into the product of the difficulty and accuracy measures. The PI formula thus was:

$$\frac{\Sigma\ (\text{assigned weight of a given test level})\ (\text{number of correct responses at that level})}{\text{number of test levels encountered}}$$

The children's PIs, psychometric scores, chronological age, and sex are presented in Table 1. Table 2 shows that the 21 children averaged in the severely retarded range of intelligence, and their typical social development, as measured by the Vineland, was also quite low.

Table 1

Summary of Children's Individual Scores

Subject	PI*	MA	IQ	VA	VQ	CA	Sex	LF
1	135.27	38	34	52	46	7.75	1	1
2	26.61	11	9	17	16	9.33	2	5
3	70.71	16	15	23	22	8.67	2	4
4	113.92	23	17	54	38	11.17	1	2
5	35.18	15	15	26	27	8.08	1	3
6	3.33	18	15	24	21	9.67	1	3
7	19.30	17	17	20	24	8.67	1	4
8	104.74	42	27	90	58	12.83	2	1
9	23.83	31	15	35	18	16.92	1	2
10	90.65	37	30	67	55	10.08	1	1
11	90.78	26	19	46	33	11.33	1	1
12	45.73	12	19	19	30	5.25	2	5
13	32.03	19	23	22	27	6.67	1	5
14	19.04	7	8	16	17	7.50	2	5
15	130.64	29	20	42	29	12.00	1	2
16	109.54	16	9	19	12	13.08	1	5
17	99.55	16	22	20	27	6.17	1	5
18	126.65	38	30	24	20	11.50	2	2
19	75.37	18	19	23	25	7.67	1	5
20	35.96	18	11	23	25	7.75	1	4
21	127.73	36	28	78	58	10.58	1	1

* PI = Performance Index
MA = Mental Age (in months)
IQ = Intelligence Quotient
VA = Vineland Social Age (in months)
VQ = Vineland Social Quotient
CA = Chronological Age (in years)
SEX = 1-Male; 2-Female
L = Language ratings

Table 2

Summary of Children's Test Performance and Chronological Age[a]

Variable	Mean	SD	Low Score	High Score
Performance Index	72.22	43.02	3.33	135.27
Mental Age in Months	23.00	10.10	7.00	42.00
IQ	19.14	7.22	8.00	34.00
Vineland Social Age in Months	35.24	21.03	16.00	90.00
Vineland Social Quotient	29.91	13.30	12.00	58.00
Chronological Age in Years	9.65	2.68	5.25	16.92
Language	3.14	1.61	1.00	5.00

[a] N = 21; 15 boys and 6 girls.

The brightness continuum. It was found that 16 of the children did not respond reliably to the pattern of 10 dots when the S- was an empty circle of equal brightness. Therefore, an opaque slide was presented as a new S-. If the child responded to a 10 versus the darkened panel, he or she was then presented with a series of eight progresively brighter S- slides. The final slide in the resulting nine-point brightness continuum was the empty circle that was as bright as the pattern of 10 dots.

Each test level consisted of 20 trials at a given level of brightness for the S-. The criteria used in the numerosity task for increasing and decreasing the difficulty of the discrimination, and for ending a session, also were used in this brightness fading procedure. If a child progressed through all nine test levels of the brightness continuum, he or she was again presented with the numerosity continuum.

Results

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With the introduction of the brightness fading procedure, 10 children eventually discriminated between 10 dots and the empty circle of equal brightness. These children did so within nine sessions: the number of trials required ranged from 90 to 430. Further, although one of these children could progress no further, the other nine were then able to progress into the numerosity continuum. One of the latter chidlren eventually succeeded at the most difficult discrimination of 10 versus nine. The other eight children succeeded at levels of discrimination varying from 10 versus one to 10 versus eight.

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$$\frac{\Sigma \text{ (assigned weight of a given test level) (number of correct responses at that level)}}{\text{number of test levels encountered}}$$

The children's PIs, psychometric scores, chronological age, and sex are presented in Table 1. Table 2 shows that the 21 children averaged in the severely retarded range of intelligence, and their typical social development, as measured by the Vineland, was also quite low.

Table 1

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Subject	PI*	MA	IQ	VA	VQ	CA	Sex	LF
1	135.27	38	34	52	46	7.75	1	1
2	26.61	11	9	17	16	9.33	2	5
3	70.71	16	15	23	22	8.67	2	4
4	113.92	23	17	54	38	11.17	1	2
5	35.18	15	15	26	27	8.08	1	3
6	3.33	18	15	24	21	9.67	1	3
7	19.30	17	17	20	24	8.67	1	4
8	104.74	42	27	90	58	12.83	2	1
9	23.83	31	15	35	18	16.92	1	2
10	90.65	37	30	67	55	10.08	1	1
11	90.78	26	19	46	33	11.33	1	1
12	45.73	12	19	19	30	5.25	2	5
13	32.03	19	23	22	27	6.67	1	5
14	19.04	7	8	16	17	7.50	2	5
15	130.64	29	20	42	29	12.00	1	2
16	109.54	16	9	19	12	13.08	1	5
17	99.55	16	22	20	27	6.17	1	5
18	126.65	38	30	24	20	11.50	2	2
19	75.37	18	19	23	25	7.67	1	5
20	35.96	18	11	23	25	7.75	1	4
21	127.73	36	28	78	58	10.58	1	1

* PI = Performance Index
MA = Mental Age (in months)
IQ = Intelligence Quotient
VA = Vineland Social Age (in months)
VQ = Vineland Social Quotient
CA = Chronological Age (in years)
SEX = 1-Male; 2-Female
L = Language ratings

Table 2

Summary of Children's Test Performance and Chronological Age[a]

Variable	Mean	SD	Low Score	High Score
Performance Index	72.22	43.02	3.33	135.27
Mental Age in Months	23.00	10.10	7.00	42.00
IQ	19.14	7.22	8.00	34.00
Vineland Social Age in Months	35.24	21.03	16.00	90.00
Vineland Social Quotient	29.91	13.30	12.00	58.00
Chronological Age in Years	9.65	2.68	5.25	16.92
Language	3.14	1.61	1.00	5.00

[a] N = 21; 15 boys and 6 girls.

Pearson product-moment correlation coefficients were computed between the psychometric and language level variables, chronological age, and the PI. Table 3 lists these correlations and shows that the PI correlated significantly with all measures except chronological age.

Table 3

Correlations between Psychometric Test Scores, Language Level, Chronological Age, and the Performance Index[a],[b]

	Performance Index
Mental Age	.65
IQ	.63
Vineland Social Age	.56
Vineland Social Quotient	.53
Language Level	.53
Age	.25

[a] N = 21; 15 boys, 6 girls.

[b] Correlations above .43 and .54 are significant at the .05 and .01 levels, respectively.

Discussion

MA and IQ have been established to be important prognostic indices for low-functioning children (Bartak, 1978). Further, the Vineland also has been found to be of prognostic value (Doll, 1953). Thus, the substantial correlations of the classification task with these measures suggest that it also may serve as an index of a child's future level of functioning. Although further research is needed to answer the question of the classification procedure's predictive validity, this is readily accomplished because the classification task lends itself to such empirical work. The PI constitutes a quantitative measure that can be correlated with other behavioral measures as children grow older.

Alpern's (1967) Infants Items Passed (IIP) test is an example of such a quantitative measure, but it was limited, as he noted, because it could not be used to establish ceilings with higher functioning children. A ceiling effect was not a problem with the present approach. Even though four children eventually reached the most difficult discrimination of 10 versus nine, the PI differentiated among them because it reflected differences in learning rate. Also, when children stabilized at the same threshold below the most difficult level, the PI differentiated among them on the basis of the number of correct responses at higher levels of task difficulty in addition to differentiating on the basis of learning rate. For example, two children both could stabilize at 10 versus four, but one might have a greater number of correct responses at 10 versus five, even though he or she could not stabilize at that higher level. Finally, it would be a simple matter to modify the classification task so that more difficult discriminations could be required (e.g., 14 vs 15) if children were evaluated who are at substantially higher levels of functioning than those of the present study.

It can also be argued that evidence for the validity of the classification task is that, while it correlates well with measures of intelligence, social functioning and language development, it does not correlate with chronological age (CA). This reasoning follows from the observations that severity of psychotic symptomatology (Alpern, 1967) and learning ability in autistic children (Varni, Lovaas, Koegel, & Everett, 1979) are independent of CA. On the basis of these observations, Alpern suggests that the greater the degree of orthogonality of a measure with CA, the more it may be considered a pure measure of a psychotic child's functioning level.

It could be argued that the large number of trials administered to some of the children in attempting to reach stable thresholds indicates that the classification task may be excessively time-consuming. However, the task could be made more efficient by a simple procedural modification. We had assumed that if a child failed to respond on a given trial, and that if he or she were adequately motivated, non-responding would reflect ability to respond. For this reason, children were returned to lower levels of difficulty if non-responding exceeded a predetermined criterion. Although this reasoning is probably sound with highly motivated (food deprived) animals, an effect of the procedure with some of the children was that many trials were required to reach stability. Therefore, we now recommend that only actual errors be used to revert to lower levels of difficulty, even though non-responding may be recorded as potentially important information.

It should be clear that we do not mean to imply that the PI is equivalent to or interchangeable with traditional indices such as the IQ score. The PI has a different, more specific focus than such global assessments. Moreover, it is evident that the obtained correlations are not sufficiently high to suggest interchangeability. It is debatable, however, whether such equivalence would be desirable. To the extent that correlations between measures exceed a certain magnitude, the measures must be regarded as providing the same information redundantly. For example, it is common to find correlations of around .80 between IQ and similarly global measures of adaptive behavior such as provided by the Vineland (Erickson et al., 1970). In the present study, the IQ-VQ correlation was .74 and the MA-VA correlation was .81. In samples of children similar to the present, we have found IQ-VQ correlations that range from .80 to .84 and MA-VA correlations that range from .80 to 89. Since a correlation of .80 implies a 64% overlap in variances, there is relatively little new information provided by these measures of social competence when a child's intelligence test scores are already known.

In contrast, the PI might reasonably be expected to provide additional information relative to that of the global measures because of its specificity of focus. Consistent with this suggestion, although the PI's correlations with the measures of intelligence and social competence were highly significant statistically, the correlations indicate that it is less redundant with these measures than they are with each other. [The typical correlations of measures of intelligence and social competence imply that no more than 36% of their variance is independent. Conversely, the correlation of PI and IQ implies that approximately 58% of their variance is independent, and the correlation of PI and VQ implies that approximately 73% of their variance is independent.] Rather than regarding the PI as a substitute for the traditional assessments, we suggest that it may be a useful adjunct or complement to these assessments.

One obvious use of the present classification procedure is in assigning children to groups in studies of various discrimination learning procedures. For example, in a comparison of stimulus fading with stimulus fading plus stimulus fractionation (cf. Schreibman, 1975), two errorless learning procedures, it would be essential to assign the children in a manner that assured pre-experimental group equivalence. Such matching would be particularly important in research with autistic children. Groups of these children typically are heterogeneous, and samples of available children are often not large enough to enable reliance on random assignment is securing pre-experimental group equivalence. Since the classification task is itself a discrimination learning procedure, the PI might well provide a better basis for goupd assignment in such studies than composite scores derived from standard psychometric tests.

Future research will be directed at assessing the general utility of the classification procedure. For example, since the discrimination learning ability of abnormal children may be regarded as important in the planning of individual educational programs, a procedure that quantifies individual differences with respect to this variable should be useful in such planning. The PI scores may be particularly useful in providing an additional basis for initial placement in education programs.

The PI may also prove to be useful in assessing a child's progress in educational programs since it reflects competence in the important areas of discrimination learning, Further, a testable question is whether increasing the difficulty of the present task would require the child to have competence in counting. In discriminating, for example, between 16 and 17, is reliable responding possible simply on the basis of differences in patterns, or would children who can count perform better than those who cannot?

Finally, as distinguished from evaluating the initial ability and progress of the child, the PI also may be useful in evaluating the efficacy of educational programming. Children provided with effective remedial training, particularly if the program has a comprehensively beneficial effect, would be expected to stabilize at higher levels of task difficulty, increase their accuracy of discriminative responding, and improve their learning rates. The present task lends itself to examining progress with respect to each of these variables.

Sustained Responding Under Intermittent Reinforcement in Psychotic Children

Rutter, Shaffer, and Shepherd (1975) suggest that the lack of perspicuous and functional systems of classification has been a major impediment to progress in childhood psychopathology. They assert that one of the most important points to emerge in the study of classification systems is the need for an experimental approach that will provide new schemas based on empirical findings rather than theoretical conceptions. Similarly, Deckner and Blanton (1980) suggested that there are advantages in classification based upon specific behavioral deficits relative to traiditional diagnosis and also relative to classification based upon global indicators such as the IQ score. Deckner and Blanton proposed an experimental approach to classify low-functioning children with respect to deficits in discrimination learning ability.

Large individual differences also exist among abnormal children with respect to another important variable, the capacity to sustain appropriate or adaptive functioning without consistent extrinsic reinforcement. Quite possibly, an important factor in the disordered behavior of low-functioning children is that they require richer schedules of feedback and/or reinforcement to maintain appropriate behavior than are available in the great majority of environmental contexts, both social and physical (Ferster, 1951). In discussions of research with infrahuman animals, Ferster and Skinner (1957) help place the study of tolerance for intermittent reinforcement in historical context. However, systematic research designed to measure schedule intolerance is lacking. The purpose of this article is to describe a procedure that classifies abnormal children on the basis of their tolerance fo intermittent reinforcement.

Optimally, any new classification procedure will provide a quantitative index of the deficit at issue that correlates with measures established to be important prognostically. As an initial step in such validation, a performance measure derived from the experimental procedure was correlated with measures of intelligence, social competence, and language functioning.

Methods

Subjects

The subjects were 6 girls and 15 boys. Study of these 21 children essentially exhausted the population of the relatively small school who were usable. The only children not included were four who were unusable because of physical handicaps or uncontrollable behavior, e.g., one girl had self-inflicted blindness through head-banging before coming to the school; another child was excused from the study after she violently kicked an experimental panel and damaged microswitches.

Psychometric Variables

MAs and IQs were obtained with either the Stanford-Binet (Form L-M) and/or the Cattell Infant Intelligence Scale. Vineland social ages (SA) and Vineland social quotients (SQ) were obtained from interviews of trainers who worked regularly with the children, and the language functioning (LF) of the children was rated according to a five-point scale as described above.

Apparatus

The computer-controlled apparatus was the same as that described above.

Procedure

The children were manually shaped to respond to a brightly illuminated panel. This was the S+ panel throughout the study. The task was designed to require minimum discrimination learning. Therefore, the S- panel was completely dark throughout the study. The position of the S+ panel was determined randomly. All that was required of the children to earn reinforcement was that they track the randomly positioned, lighted panel by pressing it whether it was on the left or on the right.

Each child was manually shaped to track the panel according to the following procedures. First, the child was required to remain seated with his or her eyes oriented toward the panels. After presentation of the S+ panel, the child's hand was placed on it, the panel was pressed, and reinforcement was presented immediately and automatically. After a variable number of such full prompts, the trainer gradually withdrew his or her manual and verbal prompts ("Push") in an attempt to have the child work independently. Reinforcement consisted of a variety of small edibles and a doorbell chime.

A large variety of edibles was used in order to minimize satiation effects that might occur if only two or three edibles were used repeatedly. During each session it was noted whether a child accepted some edibles less readily than others. If so, the less preferred edible was replaced with a mixture of edibles that had not been previously dispensed and more of the edibles that the individual continued to accept readily.

In order to promote appropriate behavior during the manual shaping phase, the discriminative stimulus was not presented until the child was seated quietly and was attending to the panel. Further, during both the manual shaping phase and throughout the subsequent test phase when the children worked alone, the following contingencies were in effect. On a random basis, one of the two side panels was lighted for a period of 10 seconds. If the child pressed the panel during the 10-second trial, the light immediately went off for a 15-second intertrial interval, a doorbell chime was activated, and an edible was dispensed. If either no response was made during the trial or the S- panel was pressed, the S+ panel was darkened for the 15-second intertrial interval.

Responding during the first 10 seconds of the intertrial interval had no scheduled consequence, but a response during the last 5 seconds postponed the subsequent trial by an additional 5 seconds from the time of the response. This time out from the opportunity to work for reinforcement was designed to place panel pressing under stimulus control. Our concern was that indiscriminate intertrial interval pressing might otherwise be maintained by advertitious reinforcement through presentation of the discriminative stimulus.

The experimenter withdrew from the room when unassisted, appropriate responding occurred on 10 consecutive trials. This completed the shaping and prompting phase. The subject was then given 20 additional trials with the requirement of tracking the lighted panel on a minimum of 80% of the block of 20 trials. During this initial block of 20 trials, as in the shaping procedure, the children were reinforced for each tracking response; i.e., they were on a 100% reinforcement schedule. If a child responded on a minimum of 80% of the trials at one level of reinforcement (e.g., the 100% level), he or she was taken to the next, slightly leaner schedule (i.e., the 90% level of reinforcement). Responding on 80% of a block of 20 trials was the success criterion that was used throughout. The level of reinforcement was reduced by 10% each time the success criterion was reached, the leanest schedule attainable being a 20% reinforcment schedule. Thus, by successfully tracking the lighted panel, a child would progress through the following sequence of nine reinforcement schedules: 100%, 90%, 80%. . ., 20%. Conversely, if in any block of 20 trials the child did not meet the success criterion, he was given additional trials at that level until he reached the success criterion. Both the edibles and doorbell chime were omitted on trials for which no reinforcement was scheduled.

The children were run for a maximum of 25 minutes each session. Sessions were ended if at any point a child ceased responding for three consecutive minutes. The children were run one session per day,usually for a minimum of four days per week. It was noted at which level of reinforcement each child ended a session. The following session, the child was begun at the next richer level of provide a "warm-up." Then, he was advanced again according to the success criterion. Each child was run a minimum of 10 sessions, assuming that the 20% level was not reached in fewer than 10 sessions.

As an assessment of stability, if a child reached the 20% schedule, he or she was given an additional session, beginning at the 30% schedule. If criterion was reached at that richer schedule, he or she was then advanced again to the 20% schedule. Children who met criterion at the 20% level on two consecutive encounters were regarded as having reached stability. Children who remained at a given richer schedule for four consecutive days without advancing were also regarded as having reached stability.

Definition of the Tolerance Measure

The sustained responding or tolerance for intermittency measure (TM) was the minimum number of trials necessary to advance beyond a level (20) divided by the actual number ot trials taken to advance. For example, a child with high levels of sustained responding might require only 20 trials at each level; i.e., he would respond on a minimum of 80% of the trials during each block of 20 trials. Therefore, his score at each level would be one (i.e., 20:20). Since there were nine levels, his total score would be the maximum attainable, nine.

In constrast, another child might show much less sustained responding and thereby require 40 trials at the first level of reinforcement before meeting the criterion for advancement. His score at that level, therefore,would be .50 (i.e., 20:40). He might might also require 60 trials at the second reinforcement level for a score of .33 (i.e., 20:30). Finally, he might not be able to meet criterion at the leaner reinforcement schedules, thus receiving zeros at each of the remaining seven levels. This child's total score thus would be .83 (i.e., .50+ .33).

Results

Table 1 shows the scores, means, standard deviations and ranges of the 21 children regarding the TM, MA, IQ, SA, SQ, and LF, along with their chronological age (CA) and sex.

Table 1

The 21 Children's Scores on Six Assessment Variables,
Their Chronological Ages and Sex

Variable	TM	MA (in months)	IQ	SA (in months)	SQ	LF	CA (in years)	Sex
Subject Number								
1	3.15	18	11	23	25	2	7.75	M
2	4.33	17	17	20	24	2	8.67	M
3	1.23	11	9	17	16	1	9.33	F
4	6.47	37	30	67	55	5	10.08	M
5	0.00	6	5	7	6	1	10.25	F
6	4.03	16	22	20	27	1	6.17	M
7	4.09	19	23	22	27	1	6.67	M
8	6.11	15	15	26	27	3	8.08	M
9	6.98	38	34	52	46	5	7.75	M
10	5.33	34	17	40	20	5	16.25	M
11	6.63	29	20	42	29	4	12.00	M
12	4.90	23	17	54	38	4	11.17	M
13	4.37	18	19	23	25	1	7.67	M
14	0.43	7	8	16	17	1	7.50	F
15	4.93	16	9	19	12	1	13.08	M
16	5.30	16	15	23	22	2	8.67	F
17	0.00	12	19	19	30	1	5.25	F
18	4.73	31	15	35	18	4	16.92	M
19	0.07	18	15	24	21	3	9.67	M

Table 1--Continued

Variable	TM	MA (in months)	IQ	SA (in months)	SQ	LF	CA (in years)	Sex
Subject Number								
20	4.59	42	27	90	58	5	12.83	F
21	0.00	26	19	46	33	5	11.33	M

	TM	MA	IQ	SA	SQ	LF	CA
Mean	2.70	21.38	17.43	32.62	27.43	2.71	9.86
Standard Deviation	2.34	10.01	7.04	19.53	12.66	1.64	3.00
Range	0.00- 6.98	6.00- 42.00	5.00- 34.00	7.00- 90.00	6.00- 58.00	1.00- 5.00	5.25- 16.92

Table 2 shows the Pearson product-moment correlations of the TM with the five psychometric variables and CA. It can be seen that the TM correlated significantly with each psychometric measure but not with CA.

Table 2

Correlations Among the TM, Psychometric Test Scores, Language Functioning and CA

Variable	TM	MA	IQ	SA	SQ	LF	CA
SRM	--						
MA	.50**	--					
IQ	.53**	.76***	--				
SA	.45*	.89***	.70***	--			
SQ	.42*	.75***	.86***	.88***	--		
LF	.43*	.88***	.58**	.84***	.65**	--	
CA	.24	.52*	.10	.40	.06	.57**	--

$^{*}p < .05$

$^{**}p < .01$

$^{***}p < .001$

Discussion

The TM differentiated satisfactorily among the children. Even though 15 children eventually reached the leanest schedule attainable, they showed measurable differences in sustained responding that determined how rapidly they attained the leanest schedule. These differences were reflected by the TM quite well, and none of these 15 children received the same score on this dependent measure. If it were desirable to differentiate among higher functioning children than those in the present study,it would be a simple matter to extend the assessment task to learner schedules than the 20% schedule that was attainable here.

The TM correlated significantly with three variables established to be important prognostically: intelligence (Bartak, 1978; Rutter, 1978), social competence (Doll, 1953), and language functioning (LaVigna, 1977; Lovaas, 1977). This finding suggests that the present classification task also may have utility as an index of a child's future level of functioning.

Utilizing edible reinforcers in the assessment of intelligence may raise questions about the generalizability of the present results with respect to intelligence since the standard assessment procedure does not entail the use of edibles. While there is relatively little research that bears directly on this question, Willis and Shibata (1978) found that tangible reinforcers produced higher IQ scores in a group of young (3.3-6.6 year-old) normal children relative to a control group that was given the standard assessment procedure. It is likely, therefore, that the intelligence test scores we obtained are somewhat higher than they would have been if assessment could have been completed with the present group without the use of edibles. Consistent with the position of Husted et al. (1971), however, we submit that the use of tangible reinforcers may achieve a more accurate assessment of an abnormal child's intelligence. Specifically, we suggest that the use of tangibles reduces the likelihood that intelligence tests scores will be spuriously low because of inconsistent motivation and attention.

Because of the TM's different focus, it would be expected to have less overlap in variance with the psychometric measures of ability than they have with one another. It is common to obtain correlations as high as .80 between measures of IQ and measures of adaptive behavior such as provided by the Vineland. The lower correlations of the TM with these measures imply that, to a substantial degree, it measures a different construct.

We suggest that there is basis for regarding the TM as relevant to the construct of motivation as distinguished from that of ability (cf. Ferster, 1961; Koegel & Egel, 1979; Siegel, 1979). Siegel states that tasks that require little or no new learning yield relatively pure measures of motivation. He argues that to the extent an assessment of motivation requires learning, motivation is confounded with ability. In the present task, once the simple response of pressing the lighted panel was learned, no new learning was required. Only the capacity to persist in making the previously learned response was necessary. Disruptions in performance were in the form of cessation of responding; there were no errors as such when responses were made at all. Thus, the children retained the discrimination even though some of them reduced or ceased their responding as the schedule of reinforcement was attenuated.

While various measures of ability already exist, we know of no operational definitions of the construct of motivation set forth for classification of abnormal children. We submit that the assessment described here has some credibility as such a measure, and that it has theoretical moorings in both operant psychology (Ferster, 1961; Koegel & Egel, 1979) and incentive motivation theory (Siegel, 1979). However, whether or not the TM is regarded as relevant to the global construct of motivation, it has clear relevance to potential deficits in a child's capacity to sustain adaptive responding. We submit that deficits in that capacity are sufficiently important to warrant specific assessment.

The absence of correlation between the TM and CA is noteworthy. Alpern (1967) and Varni, Lovaas, Koegel, and Everett (1979) suggest that the greater the degree of orthogonality of a measure with CA, the more it may be considered a pure measure of an abnormal child's functioning level.

It may be relevant to note that we considered progressively enriching an initially lean schedule of reinforcement in addition to progressively attenuating an initially rich schedule. In some contexts there are advantages in using both ascending and descending series with respect to the demands of a task in determining functioning level; for example, in psychophysical research designed to establish perceptual thresholds in normal adults. We were concerned, however, that initially exposing the children of the present study to frequent extinction trials would evoke negative emotional behavior and resistiveness to the task that would result in assessments of functioning level that were artifactually low. Our view is that if a child does not progress beyond a particular point when task demands are increased gradually, this constitutes a substantially more accurate assessment of functioning level than when he has frequent failure experiences early in his exposure to a task.

Despite the TM's significant correlations with the psychometric variables established to be important prognostically, whether the experimental assessment will have predictive utility must be determined by future research. One virtue of the TM, however, is that it lends itself readily to such empirical work. The present classification task provides a quantitative measure that can be correlated with other behavioral indices as children grow older.

Regarding the potential utility of the classification task, children who require continuous reinforcing attention cannot function in a standard classroom where reinforcement from teacher attention is necessarily partial and schedules may be very lean for some children. Being able to measure tolerance for lean schedules may therefore be useful in enabling us to predict adaptation to group-learning settings more adequately. The TM may be particularly useful in providing an additional basis for initial placement in educational programs. For example, it may help predict the child-to-teacher ratio an individual child will require.

A virtue of the present procedure is that it is applicable with children at various levels of functioning including those who have little or no receptive language. With children who cannot be verbally instructed as to the requirements of the task, it is necessary initially to employ shaping procedures in order to have them track the correct stimulus as the schedule of reinforcement is attenuated. Particularly with such nonverbal children, application of the procedure requires substantially more time than assessments that only require ratings made by adult observers, e.g., the Vineland. On the average, the procedure also takes somewhat more time than the administration of a standard intelligence test. Since traditional assessments yield global indicators and do not provide information concerning specific deficits, however, experimental assessments such as the present may be of practical utility despite their being more time consuming to implement.

In conclusion, we submit that the experimental measure has good face validity with respect to assessing the specific dimension it was designed to assess, viz., the capacity to sustain adaptive responding without consistent extrinsic reinforcement. We also note that individual differences along this dimension are clearly important in the study of abnormal children and that they are not specifically and quantitatively assessed by existing measures. These considerations suggest that the additional research necessary to establish the measure's predictive utility may be a worthwhile undertaking.

Autoshaping of Abnormal Children*

Many animal species have been found to acquire various responses as a function of stimulus-reinforcer pairings, even in the absence of a response-reinforcer contingency (see Hearst & Jenkins, 1974, for a review). Brown and Jenkins (1968) called performance under these conditions autoshaping, and they distinguished between two operations that produce such performance. In the prototype of "forward pairing," a manipulandum is periodically lighted, and if there is no response within a specified interval, the light is turned off and reinforcement is delivered; if, however, a response is emitted, the light is turned off and reinforcement is delivered immediately. Thus, this procedure entails both a stimulus-and a response-reinforcer dependency. In "fixed duration" autoshaping, the lighting of a minipulandum is always followed by reinforcement, and presentation of the reinforcer is not affected by responding. Fixed duration autoshaping can be regarded as a classical conditioning procedure because it involves only a stimulus-reinforcer dependency.

Recently, Atnip (1976) found that both forms of autoshaping and operant conditioning (in which responding is necessary for reinforcement) generated lever pressing in rats. Of the three procedures, acquisition was fastest with the forward pairing procedure. Forward pairing also produced stable, high rates of responding most rapidly and was associated with the least intersubject variability.

Because of the difficulties in training abnormal children, who often are highly oppositional and negativistic, we fealt that it would be important to use the most effective of the three shaping procedures. Typically, such children are "hand shaped" to operate experimental apparatus and training devices. In the usual hand shaping procedures, a child is required to remain seated with his or her eyes oriented toward the manipulandum. During a trial, which may be signalled by the lighting of a panel, the child's hand is placed on the panel, the panel is pressed, and reinforcement is presented. After a number of such full prompts, the trainer gradually withdraws the manual and verbal prompts until the child works unassisted.

Fading prompts in a manner that is sensitive to the child's performance is an art that requires considerable experience. Unfortunately, there is much subjectivity and unreliability in manual shaping, dur to inconsistency among trainers and within the same trainer at different times. Therefore, it would be of practical consequence if such initial training could be standardized. This is particularly true in view of the reasons for believing that "teaching machine" technology should be effective both from a training standpoint and from the standpoint of saving the time of expensively trained personnel who usually must work with low-functioning children individually (cf., Colby, 1973; Russo, Koegel, & Lovaas, 1978).

Manual shaping also may be inherently limited and potentially problematic. A manual prompt can be regarded as a type of extra-stimulus prompt: the prompt, i.e., the trainer's manual shaping, is not a part of the stimulus to which the child is to respond ultimately. Schreibman (1975) demonstrated that extra-stimulus prompts interfere in both auditory and visual discrimination learning with psychotic children. Our difficulties in establishing reliable panel pressing with a substantial percentage of abnormal children similar to those described below suggested the potential relevance of Schreibman's findings to hand shaping, a procedure commonly used in applied settings.

Conversely, Schreibman showed that within-stimulus prompts have a potent facilitative effect. In within-stimulus prompting, some integral feature of the stimulus is exaggerated or made more conspicuous during initial phases of training. Lighting the manipulandum itself, as in autoshaping, can be regarded as a within-stimulus prompting procedure.

In view of these practical considerations, we felt that it would be of value to examine autoshaping as a training procedure with low-functioning and psychotic children. We expected that simply exposing children to a terminal operant contingency would be relatively ineffective in generating responding. As discussed above, however, the animal literature suggested that the forward pairing autoshaping procedure would be an effective, standardized shaping technique. Therefore, the original experimental

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design was to begin training with the operant procedure without using either manual shaping or successive approximations by remote control. The only requirement was that the child be seated at the beginning of the training session. Using a multiple baseline design across subjects, we then intended to make shifts within sessions to forward pairing. As is elaborated below, however, unanticipated findings required a change in strategy from using forward pairing to fixed duration autoshaping.

Method

Subjects

Three male children who were the most recent admissions to the school were studied. Two of them were consistently difficult to control and one was episodically difficult to manage. All three were subnormal in functioning, and none had had prior exposure to an experimental apparatus of any kind.

The following observations were made during the children's present school placement. Quoted statements constitute diagnostic and descriptive information obtained from records of independent attempts to evaluate the children in other institutions.

Subject R, who was 5.6 years old, was extremely hyperactive. He had high rates of pica and high-pitched vocalizations, but never used intelligible words. R's only indication of receptive vocabulary was inconsistent responding to a few simple verbal commands. R had no appropriate toileting behaviors. He sometimes engaged in self-injurious behavior (head banging), and he often attempted to bite and pull the hair of other children. "Extremely uncontrollable." Regarding his behavior in a testing situation: "He would reach for objects and pull things off shelves and tables...and throw them on the floor. He would not sit, and ran around the room or crawled on the floor." "No formal testing was accomplished due to [R's] hyperactive behavior."

Subject K, who was 12 years old, was hypoactive, almost entirely mute, and usually withdrawn. In addition, he was highly oppositional and episodically assaultive, typically when a trainer attempted to work with him. Also, he sometimes had to be restrained from attacks on other children. Although K had toileting skills and a slightly larger receptive vocabulary than subject R, he often displayed bizarre behaviors such as forcing his fingers into his anus followed by sniffing his fingers. "When [K] vocalizes, he screams. He has no language at all." "[K] was unable to respond to the Peabody Picture Vocabulary Test." "The overall impression is that [K] seems to be primarily an emotionally disturbed child with mental retardation as a secondary handicapping condition." "He is self-abusive to the point that he makes himself bleed."

Subject J, who was 3.6 years old, was the highest functioning of the three. Relative to the other two subjects, he was less bizarre, but was sometimes difficult to manage. He frequently engaged in head banging when frustrated. He had the largest receptive vocabulary of the three, and he had a small expressive vocabulary. "Possible childhood psychosis." "Global developmental delay." "Hyperkinetic syndrome." "Significant speech delay." "Assessment with the Stanford-Binet and Peabody Picture Vocabulary was attempted, but discontinued due to the severity of his behavior. Most of his behavior lacked purpose and was dangerour to self and others."

Apparatus

The apparatus was computer controlled and has been described in detail above.

The training took place in a 3.35 m by 2.67 m room that had a one-way mirror in a side wall and contained a chair for the subject placed directly in front of the center panel. The room provided minimal muting of the few extraneous sounds from the computer in the adjacent room.

Procedure

In order to determine the food preferences of each child, and in order to give the children time to become accustomed to being left alone in a strange room, an adaptation procedure was employed before training began. The children were taken individually to the experimental room and seated. A variety of 20 small edibles was in the food tray directly in front of the child. As soon as the child ate the food, he was removed from the experimental room. This adaptation procedure was followed for three sessions per child. It was noted whether the children avoided any of the food items and whether they showed any emotional behavior in response to being placed in the room. When it was evident that the children were not disturbed about being left alone in the room, the operant conditioning phase began.

Phase One: Exposure to a Terminal Operant Contingency

The experimenter seated the child at the beginning of each session. After the experimenter left, there was no other human intervention during the remainder of the session. Periodically, a light went on and off, alternately illuminating and darkening the middle panel. If the child pressed the panel during the 25-sec trial (T), the light immediately went off, a door bell chime was activated, and an adible was dispensed. Responding during the first 30 sec of the 35-sec intertrial interval (ITI) had no scheduled consequence, but a response during the last five sec of the ITI postponed the subsequent trial by an additional five sec from the time of the response. This time-out (TO) from the opportunity to work for a reward was designed to place panel pressing under stimulus control; our concern was that indiscriminant ITI pressing might otherwise be maintained by adventitious reinforcement through presentation of the discriminative stimulus.

Within the multiple baseline across subjects design component, subject R was administered 50 trials of the terminal operant contingency, subject J had 90 trials, and subject K had 130 trials.

Results

The three children acquired the panel press response within a surprisingly small number of trials. The numbers of trials to the first response was one, 27, and two for R, K, and J, respectively. Each of the children made his first response within the first session. Figure 1 shows the percentage of trials on which there was a response to the lighted panel during each block of 10 trials. It is apparent from Figure 1 that in Phase One the children stabilized in responding on 100% of the trials within a relatively small number of trials: R stabilized by the second block of 10 trials of the first session; K stabilized by the fourth block of the first session; and J stabilized by the second block of the second session.

Discussion

The phase One data are consistent with Atnip's (1976) observations with rats and Lewis and Stoyak's (1976) findings with pigeons. It should be noted that Phase I conissted not only of a demonstration of a response being placed under stimulus control. The initial acquisition of responding might be characterized as the signal generation of a response *de novo*. However, our initial rationale for shifting the children to the forward pairing procedure no longer was applicable. That is, the forward pairing procedure could not be demonstrated to be more effective because of the ceiling effect imposed by the findings with the operant contingency. Further, there is much similarity between operant and forward pairing procedures when subjects respond frequently and rapidly. We felt, therefore, that there was a low probability that a shift from operant to forward pairing would be discernible to the children and that, consequently, it was unlikely that this transition would produce interesting effects. A more conspicuous contingency change is afforded, however, by a shift from an operant contingency to the fixed duration autoshaping procedure. Therefore, a transition to the classical conditioning form of autoshaping was implemented in Phase Two.

Phase Two: Classical Conditioning

The classical conditioning procedure was introduced to the children on a sequential basis according to a multiple baseline design across subjects. Subsequently, a reversal to the operant procedure was implemented with K and J; R was shifted from operant to classical and then back to operant. R was not given classical the second time because his responding did not recover in the second operant phase.

The temporal parameters for T, ITI, and TO were the same as those of Phase One. As in the prototype classical conditioning paradigm, the presentation of the stimulus was perfectly correlated with subsequent presentation of food, and food presentation was not contingent on a response. This meets the requirement of the autoshaping procedure since the stimulus is predictive of the reinforcer (Schwartz & Camzu, 1977).

Results

Figure 1, Phase Two, shows that the classical conditioning procedure quickly disrupted the stable rates of responding associated with the operant procedure. On some blocks of 10 trials, each of the children made no response at all. During the last 40 trials of the classical phase, R made only four responses; J made only six; and K made only three.

Figure 1, Phase Three, shows that the suppressive effect of the classical procedure was not reversible by reinstatement of the operant procedure for R: he made only two responses in 110 trials. Furthermore, although this suppressive effect was ultimately reversible with J. and K, these children took a substantial number of trials to recover. J made only 36 responses in the first 100 trials, although he responded on 76 of the remaining 80 trials. K made only 28 responses in the first 80 trials, although he responded on all of the remaining 80 trials.

Figure 1, Phase Four, shows that the disruptive effect of the classical procedure was replicated with J and K. Again, there were some blocks of a minimum of 10 trials during which the children made no response at all. In general, responding was variable and much lower than in the preceding operant phase.

Table 1 is a summary of the data from all phases of the study. It includes the first trial on which there was response emission during the operant phases and the first trial on which there was response omission during the classical phases. One notable finding is that it took the children more trials to re-acquire the discriminative response in the second operant phase than they had taken to acquire this response in the first operant phase.

Table 1

Trial in Which First Response Was Emitted During
Operant (0) and Omitted During Classical (C)
Phases, Subjects R, J, and K

	Phase			
Subject	0_1	C_1	0_2	C_2
R	1	28	33	--[a]
J	2	17	19	3
K	27	9	42	7

[a] Subject R was not exposed to phase C_2 because his response rate during 0_2 was virtually zero.

There also was informal evidence that the shift from operant to classical contingencies was associated with negative emotionality in all three children. In this regard, R began agitated rocking and emitted loud utterances. J, the only child with expressive vocabulary, began to complain to the panel with the statement: "Turn it [the light] off!" He also began agitated rocking. During the second classical phase, he again displayed emotional behavior, but of a more intense nature. In fact, because of his crying, this phase was terminated earlier than we had planned. K wet his pants and began to masturbate during the initial part of the first classical phase. In the second phase, he became passive and withdrawn. These behaviors did not occur during either of the two operant phases.

The children struck the panel repeatedly and more forcefully during the early trials following the shift from operant to classical, but then greatly reduced their rates of responding under the classical condition.

Discussion

The results obtained in Phase One indicate that signal-controlled responding (Lewis and Stoyak, 1979) can be established very rapidly with some abnormal children. This is consistent with the animal literature (cf. Atnip, 1976; Meyer & Hull, 1974; Lewis & Stoyak, 1979). Furthermore, Zeiler (1972) made reference to unpublished findings showing that forward pairing autoshaping occurs with four- and five-year-old normal children. However, to our knowledge there are no previous published reports of efforts to use autoshaping or signal-control procedures with abnormal children.

It was noted that one of the children used in this study was five years old and another only 3.6 years old, the latter thus even younger than the normal children whom Zeiler (1972) mentioned. Zeiler reported that each of the normal children pressed a key during either the first or second training session, with the first press occurring somewhere in the middle of the session. Although Zeiler's brief description did not include a citation of the number of trials per session, two of the three children in the present study responded to the lighted panel almost immediately.

Reportedly lighting a minipulandum that the trainer wishes a child to operate thus appears to be an efficient procedure for shaping children to use apparatus. Although questions of generality remain, the procedure can be regarded as a useful screening technique to determine if specific abnormal children can appropriately respond to experimental apparatur without shaping. If a child can acquire a desired response without hand shaping or successive approximation, considerable time may be saved. As noted, hand shaping may in fact have serious drawbacks with psychotic children because it consists of extra-stimulus prompting (Schreibman, 1975).

It may be noted that there was no pre-experimental assessment of responding to the panel without reinforcement. Thsi type of baseline was not included because our original intention was to evaluate the effectiveness of forward pairing autoshaping against the baseline provided by exposure to a terminal operant contingency. As indicated, we had experienced difficulty in establishing panel-pressing with a number of abnormal children using hand shaping, fading and continuous reinforcement, and we had anticipated that simply exposing such children to the terminal operant contingency would not generate responding. Further, we were concerned that if initially there were unreinforced responding to the panel, this extinction experience might well evoke negative emotionality from the children and would provide an artificially or atypically adverse baseline condition for response acquisition.

In addition to suggesting the potential relevance of Schreibman's (1975) findings, it was the problems that we encountered with conventional hand shaping that stimulated our interest in autoshaping as a potentially more effective procedure. Efficient techniques that would enable abnormal children to interact appropriately with training devices would be of considerable habilitative value.

The suppressive effect of the classical conditioning form of autoshaping is not consistent with findings of a number of animal studies that indicate that the procedure generates and maintains responding. Indeed, the repeated stimulus-reinforcer pairings of the autoshaping procedure have been demonstrated to establish steady rates of responding even when opposed to a negative response-reinforcer contingency, i.e., a response cancels presentation of programmed reinforcement (e.g., Atnip, 1976; Williams & Williams, 1969). However, the stimulus-reinforcer pairings substantially suppressed response rates in Phases Two and Four of the present study.

Procedural differences may account for the discrepancy between the findings of this study and what has been reported in the literature. In the present study (a) there was a longer (25 sec) trial time, and (b) the classical form of autoshaping immediately followed the operant conditioning procedure. Most animal studies have used shorter trial times than that of the present study. Representative are Brandon and Bitterman (1979), who used 10 sec and Atnip (1976) who used 8 sec. In his study of normal children, Zeiler used a 6-sec trial time. Further, to our knowledge, no previous studies have subjected ongoing operant behavior to the autoshaping procedures as was done in the present study.

With these differences in mind, the literature on contrasted conditions of reinforcement (Dunham, 1968; Schwartz & Gamzu, 1977) seems to provide a basis for accounting for the results of this study. Specifically, this literature suggests that the disruptive effects of the classical conditioning procedure were due to negative behavioral contrast. In this regard, the shift from the operant phase to the classical phase resulted in a conspicuous increase in the dealy of reinforcement. By responding, the children could produce reinforcement immediately during the operant phase; however, they had to wait a full 25 sec in order to obtain reinforcement in classical phase.

Dunham (1968) cited findings from various animal studies that show a biphasic effect is reliably produced by such contrasting conditions of reinforcement. Initially the shift from a more favorable to a less favorable reinforcement condition facilitates or amplifies responding; subsequently, there is a reduction of responding. This effect is attributed to the "assumed emotional effects" of the shift. "More specifically, it is suggested that the initial reaction to contrasted conditions of reinforcement is an increase in general rate or speed of responding prior to the discrimination of the appropriate response requirements for the changed conditions. Following the acquisition of the required discrimination, the performance adjust to a level appropriate to or below the absolute conditions" (Dunham, 1968, p. 313). Such a biphasic effect on panel pressing, with evidences of concomitant emotional behavior, seems an apt description of the findings obtained in the present study.

Although a number of studies have compared autoshaping with operant conditioning, apparently no previous studies have contrasted them by means of the sequential presentation that was employed here. The results of this study suggest that the negative behavioral contrast produced by the operant-classical sequence exerts s suppressive effect that overrides the response-generating effect of stimulus-reinforcer pairings that is quite powerful in other contexts.

In conclusion, the interpretation suggested for the finding of response disruption requires substantiation by further research. However, from the standpoint of ongoing efforts at systematic replication, this finding is of interest in itself in that it is substantially at variance with previous observations regarding autoshaping.

Relationships Among Two Experimental and Four Psychometric Assessments

Regarding nosology of abnormal children, Rutter, Shaffer, and Shephard (1975) suggest that an experimental approach can both elucidate sources of disagreement that have long bedeviled progress and communication in this sphere and also show how closer agreement can be obtained. These investigators conclude that one of the most important points to emerge in the study of classification system is the need for new schemas based on empirical findings rather than theoretical models.

We have shown above that large individual differences exist among abnormal children with respect to discrimination learning ability as well as the capacity to sustain appropriate or adaptive functioning without consistent, extrinsic reinforcement. Quite possibly, an important factor in the disordered behavior of low-functioning chidlren is that they require richer schedules of feedback and/or reinforcement to maintain appropriate behaviors that are available in the great majority of environmental contexts, both social and physical (Ferster, 1961). However, systematic research designed to measure and ameliorate such schedule intolerance is lacking. We examine here the relationships between the two experimental measures of discrimination learning ability and schedule intolerance with the psychometric measures described above.

In addition to the measures described above, the two experimental asessements were correlated with the Rimland Scale, a measure regarded to be important diagnostically, are reported. The Rimland Scale is used in differential diagnosis to assess the extent to which a child approximates Kanner's syndrome, classical autism (Rimland, 1971).

The children's parents who could be located were mailed copies of the Rimland Scale, Form E-2, with a cover letter requesting completion of the retrospective checklist. A follow-up mailing was made to parents who did not respond to the initial mailing. It was possible to obtain completed E-2 forms from parents of 14 of the children.

Results

Table 1 shows the means, standard deviations and ranges regarding the TM and PI, the psychometric variables, and CA. Table shows the correlations among these assessment variables and CA. Unfortunately, the school that provided residence for the present sample of children went bankrupt, resulting in the scattering of the children before both experimental measures could be obtained on all children. Consequently, the TM correlations are based on an N of 15 children while all other correlations are based on an N of 18. Table indicates the level of significance of each correlation at the appropriate degrees of freedom.

As can be seen, the PI correlated significantly with the psychometric variables. However, the TM correlated only with PI, MA, and IQ. Neither of the experimental assessments correlated significantly with CA.

Table 2 shows the correlations of the two experimental assesments and the psychometric variables with measures based on the Rimland Scale. The latter test is broken down into its two components, behavior and speech, as ordinarly

Table 1

Means, Standard Deviations (SD), and Ranges of the Experimental Assessments, the psychometric assessments of ability, and CA

Variable	Mean	SD	Range
TM	39.01	31.24	20.22 - 147.94
PI	70.70	40.40	10.03 - 135.27
MA	22.44	10.24	7 - 42[a]
IQ	18.89	7.28	8 - 34
SA	35.44	21.96	16 - 90[b]
SQ	30.50	13.87	12 - 58
LF	3.28	1.69	1 - 5
CA	9.46	2.83	5.25 - 16.92[c]

Table 2

Correlation Matrix of the Indicated Variables

Variable	TM	PI	MA	IQ	SA	SQ	LF	CA
TM	--							
PI	-.48*	--						
MA	-.52*	.64**	--					
IQ	-.50*	.62**	.79***	--				
SA	-.33	.61**	.92***	.73***	--			
SQ	-.35	.58**	.82***	.87***	.92***	--		
LF	-.41	.54**	.90***	.65**	.87***	.76***	--	
CA	-.21	.21	.52**	-.05	.42	.06	.52**	--

*$p < .05$

**$p < .02$

***$p < .01$

Table 3

Correlations of the Experimental and Psychometric Assessments
with the E-2 Variables

Variable	TM	PI	MA	IQ	SA	SQ	LF	CA
E-2 Behavior	-.12	.42	.39	.43	.33	.28	.34	.23
E-2 Speech	-.42	.60**	.79***	.66***	.75***	.77***	.75***	.20
E-2 Total	-.25	.52*	.62**	.62**	.54*	.51*	.56*	.29

$^{*}\underline{p} < .05$

$^{**}\underline{p} < .02$

$^{***}\underline{p} < .01$

scored at Rimland's Institute of Child Behavior Research. Designed to be a quantitative assessment of the degree to which a child has features of autism, the E-2 may yield negative speech and/or behavior scores because the number of non-autistic signs is subtracted from the number of autistic signs. To avoid the problem negative numbers pose in computing correlations, a constant of 25 was added to each child's behavior score and also to each child's speech score.

Table 3 indicates the level of significance of each correlation at the appropriate degrees of freedom (12 for the TM and 14 for all other variables). It can be seen that the PI correlated significantly with the total E-2 score and the speech component but not with the behavior component. A comparison indicates that the psychometric assessments had the same pattern of correlations with the E-2 variables. Conversely, the correlations of the TM with the E-2 variables did not reach significance.

Discussion

For some years, investigators in childhood psychopathology (Rutter et al., 1975) and mental retardation (Leland et al., 1967) have called for multiaxial systems of classification. They assert that unidimensional indices such as an IQ score are insufficient to differentiate among children who are conspicuously different in important ways, even though they may be identical on the single dimension that is assessed. The two experimental assessments described here might reasonably be expected to provide bases for differentiation that do not have excessive overlap with existing measures. The PI was designed to focus specifically on discrimination learning ability. Its correlations with the measures of intelligence and social competence were moderately high, but the correlations indicate that it is less redundant with these commonly used measures than they are with each other (Deckner, Soraci, Deckner, & Blanton, in press; Erickson et al., 1970). The magnitude of the correlations obtained probably should be expected since the PI is a measure of ability, as are the two psychometric assessments.

Conversely, the TM can be construed as conceptually closer to the construct of motivation than to that of ability (cf. Ferster, 1961; Koegel & Egel, 1979; Siegel, 1979). Siegel (1979) suggests that tasks that require little or no new learning yield relatively pure measures of motivation. He argues that to the extent that an assessment of motivation requires learning, motivation is confounded with learning ability. It was noted that once the simple response of pressing the lighted panel was learned in the assessment of tolerance for intermittency, no new learning was required. Only the capacity to persist in performing the previously learned response was necessary. Once a child acquired the simple discrimination involved, disruptions were in the form of cessation of responding; there were no errors as such if responses were made at all. Thus, the children retained the discrimination even though some of them reduced or ceased their responding as the schedule of reinforcement was attenuated.

If the TM more directly assesses motivation than ability, it would be expected to have lower correlations with the global measures of ability than the PI. Table idicates that this was consistently the case. Regarding the magnitude of the correlations that were obtained, it may be noted that children's scores on ability measures, including intelligence tests, the Vineland and the PI, are importantly influenced by their motivation to perform. The correlations obtained between the TM and the ability measures therefore may be attributable to their mutual dependence on children's motivation to respond appropriately.

Because the two experimental assessments focus on specific behavioral deficits, they are likely to be of greater prescriptive value than global indices such as an IQ score (Koegel, Egel, & Dunlap, 1980). In fact, greater exposure to the assessment procedure themselves might have an ameliorative effect on important deficits. The discrimination learning task incorporates an errorless learning procedure, fading, that has been established to promote discriminative responding in both animals (e.g., Terrace, 2963) and abnormal children (e.g., Schreibman, 1976).

Similarly, the assessment of schedule tolerance gradually exposes children to greater degrees of intermittency in a manner that is sensitive to the individual child's responding. Recently, Koegel, Schreibman, Britten, annd Laitinin (1979) demonstrated that exposing autistic children to partial reinforcement schedules ameliorated their highly maladaptive "over-selective attention." A potential problem in this regard is that a significant percentage of abnormal children do not sustain their responding under partial reinforcement (Ferster, 1961). However, with training, rather than assessment, as the objective, it is reasonable to hypothesize that many gradual approximations of lean schedules would eventually have a beneficial effect on a child's tolerance for intermittency. Koegel and Egel (1979) demonstrated that exposure to an 80% reinforcement schedule had a beneficial effect on autistic children's perserverance. These authors regarded their intervention as improving the children's motivation.

It may be relevant to note that we considered using a descending series with respect to the demands of the two experimental tasks in addition to the ascending series that was used. In general, there are advantages in using the two types of series in conjunction; e.g., in classical psychophysical research designed to establish perceptual thresholds in normal adults. We concluded, howevver, that with our children these advantages were outweighed by potential problems. In the tolerance assessment, a descending series would consist of beginning with the leanest schedule and progressively enriching it. In the discrimination learning assessment, a descending series would consist of beginning with the most difficult discrimination and progressively reducing the difficulty. In similar experimental contexts with subjects from the same population of extremely low-functioning children, we have observed that increasing the demands of a task too rapidly often evokes negative emotional behavior and resistiveness to the task that have long-lasting, deleterious effects on performance. Under that circumstance, assessment of functioning level are obtained that are spuriously low. Conversely, we have observed that such problems are less likely when the probability of the children committing errors and/or experiencing extinction trials is initially minimized. In general, our view is that when a child cannot progress beyond a given point when task demands are increased gradually, as in a fading progression, this consistutes a substantially more accurate assessment of functioning level than when he is subjected to frequent failure experiences early in his exposure to a task.

The PI correlated significantly with the E-2 total score and speech component, but not with the behavioral component. It may be noteworthy that this is the same pattern of correlations that the psychometric assessments had with the E-2 variables. All of the children in the present study were markedly abnormal. These considerations may indicate that, to the extent that the E-2 correlates with the measures of functional adequacy, children who are abnormal in an autistic sense tend to be higher functioning than those who are abnormal in a non-autistic sense. The failure of the TM to correlate significantly with the E-2 variables may have adverse implications for the utility of the assessment of schedule tolerance. However, a plausible alternative interpretation is that impaired tolerance for intermittency is not peculiar to children who display features of classical autism but is also an impairment in other forms of childhood psychopathology. All of these possibilities require additional research for substantiation.

An encouraging finding regarding the potential utility of the two measures may be noted. While two of the children reached the most difficult discrimination attainable, they showed measurable differences in learning rate that were reflected in the PI. Similarly, while 13 of the children reached the leanest schedule attainable, they showed measurable differences in sustained responding that were reflected in the TMM. Thus, a ceiling effect was not a problem with the two dependent measures; they differentiated satisfactorily even among the highest functioning of the children.

If higher functioning children than those of the present study were assessed, it would be a simple matter to increase the ultimate requirements of the two experimental tasks. For example, discriminations between 14 and 15 dots and tolerance of a 10% reinforcement schedule could be required. Further, in assesing higher functioning children, it might be desirable to introduce test probes following attainment of each level to determine if the child could then skip directly to the most demanding level. A "savings" score that reflected trials or levels that did not have to be administered might be utilized.

In conclusion, the experimental assessments tended to correlate with measures established to be important prognostically, i.e., intelligence, (Bartak, 1978; Rutter, 1978), social competence (Doll, 193), and language fucntioning (LaVigna, 1977). While this suggests that the experimental measures also may be useful prognostically, the extent to which the PI and TM will have prognostic and classificatory utility is a question that must be answered by future research. We submit, however, that these measures have good face validity with respect to the specific dimensions they were designed to assess, namely, discirmination learning ability and tolerance for intermmitent reinforement. We also note that these dimensions are clearly important in the study of abnormal children, and that they are not specifically and quantitatively assessed by existing measures. These considerations suggest that the necessary additional research may be a worthwhile undertaking.

The Relationship Between Rate of Rhythmicity and Stereotypic Behaviors

The stereotypic behaviors observed in developmentally delayed children are usually of a rhythmic, repetitive nature, and are often dscribed as "autisms" and forms of "self-stimulation" (Berkson & Mason, 1964; Guess, 1946). For example, rocking appears to be one of the most frequently observed and topograhically invariant behaviors among mentally retarded individuals (Baumeister & Forehand, 1973). Luckey, Carpenter, and Steiner (1967) found an increase in such rhythmic motor activity with mentally retarded adults when rhythm band instruments were used. Indicative of the sensitivity of even profoundly psychotic individuals to auditory stimulation, Applebaum, Egel, Koegal, and Imhoff (1979) demonstrated that autistic children performed as well as, and in some cases better than, normal children on a test that measures the children's accuracy of imitation of the pitch, rhythm, and duration of a musical tone.

In consideration of (a) the demonstrated sensitivity of developmentally delayed children to auditory stimulation, and (b) the potential compatibility of rhythmic musical structure with the topography of stereotypic behavior (e.g., tempo and frequency), the present study was designed to examine the effet of rhythmic, auditory stimulation on the frequency of sterotypies observed in mentally retarded children. Several previous studies have focused on the effects of the intensity of auditory stimulation on subjects from this population (Forehand & Baumeister, 1973; Levitt & Kaufman, 1965). There is evidence that increases in ambient noise levels per se generate increased rates of rocking (Baumeister & Forehand, 1973). However, the effect of rate of stimulation has not been systematically investigated. The variable of rate is interesting theoretically because the perception of rate, or tempo, of rhythmic auditory stimulation implies perception by the individual over time, a dynamic process. Gibson (1966) has spoken of perception as the detection of information. The perception of rate of rhythmicity would be a relatively sophisticated detction of higher-order, invariant information: i.e., the detection of time-based, auditory information.

Stevens (1971) found some evidence that tempo changes influenced sterotypic rocking movements of severely retarded children. Stevens' subjects had been classified as either low, middle, or high frequency rockers. Although she did not find a consistent relation between the variables of rocking and tempo changes across all subjects, there was a tendency for children who were high frequency rockers to decrease this particular stereotypy at the slow tempo rate. Chilcote-Doner (1981) has demonstrated that autistic children wiill actively select auditory and visual repetitive stimulation when given the opportunity.

The present study was designed to examine the variable of rate by measuring a number of operationally defined overt behaviors under four conditions of rhythmic stimulation. Our hypothesis was that over the four rhtymic rates, a curvilinear (inverted u-curve) relationship would be observed for specific behaviors. Specifically, we predicted that rate of rhythmicity and behavioral stereotypies would positively covary up to a certain point, and then negatively covary due to a perceived loss of rhythmicity at the higher rate.

Despite the foregoing theoretical expectation, we should note that any condition of rhythmicity that is associated with low rates of potentially maladaptive behaviors may be of practical importance. That is, from the standpoint of therapy it is not crucial that the relationship between frequency of stereotypies and rate of rhythmicity have the specified curvilinear pattern. So long as a nonaversive auditory intervention can be introduced that reduces the frequency of a child's behaviors that set him or her apart from normal children and that impair his or her ability to learn (Lovaas, Litronik, & Mann, 1971), this in itself is the important consideration from the standpoint of music therapy.

Method

Subjects. The subjects were 11 Walden House children unequivocally diagnosed as functioning in the mental retardation range. They were classified as either high-, middle-, or low-range of retardation by the professional staff of the agency from which they were obtained. Their average age was 7 years, and they ranged in age from 5 years to 10 years. Each of these children displayed high rates of one or more forms of stereotypic behavior.

Stimuli. The same instrumental soundtrack was used in all four experimental conditions. This particular soundtrack was chosen because it maintained a constant rhythmic pattern throughout. This soundtrack, entitled "Soul Sacrifice" by the group Santana, was tape-recorded at 78, 45, 33, and 16 rpm. The speed at which the soundtrack was originally recorded was 33 rpm. The resulting four experimental tapes were each of three minutes duration. The intensity, or volume, of the soundtrack was held constant throughout all conditions.

Procedure. Each subject was observed individually in one of two small rooms provided by the school where the children were enrolled. Each experimental session was three minutes in length and was divided into 32 five-second blocks. Each five-second block was designated on an alternating basis as either an "Observe" or "Record" block. The observers were cued by a timer as to which block of time was now in progress (Observe or Record). The total observation time per session was one and one-half minutes, and the total recording time was exactly the same. A previous study employing this observational technique indicated that three minutes was sufficient for there to be emission of the behaviors of interest. Further, abnormal children tend to become agitated if such unstructured sessions are longer than three minutes (McDaniel, 1978; Chilcote-Doner, 1979). This last consideration made it necessary to present only three of the four tape speeds to each subject on any given day. The order of presentation of speed levels was counterbalanced.

For each child, the frequency of each of the following five behaviors was recorded.

1. Rocking whole body side to side or back and forth.

2. Idiosyncratic, stereotypic behaviors that could be easily defined

for each child prior to the observation session.

3. Rhythmic behavior clearly in time to the music, with hands or feet.

4. Vocalizations: Talking, screaming or other sounds, none of which were communicative in intent.

5. Fidgeting: Behaviors that did not appear related to the rhythmicity of the soundtrack in a synchronous way (e.g., scratching).

The defining characteristics of the five behavior categories were determined and agreed upon by the observers prior to conducting the study. A number of idiosyncratic stereotypic behaviors were defined for each child. The latter behaviors were recroded separately but later combined for purposes of data analysis.

Either one or two observers, equipped with a digital timer, was employed in each observational session. Ten inter-rater reliability checks consisting of 1440 independent observations were performed at random intervals throughout the study. To increase the validity of these checks, several observers naive with respect to the purposes of the study, observed the subjects. The reliability quotient (agareements divided by agreements plus disagreements) was approximately [illegible]4%.

The frequency of occurrence of each of the behaviors during the "Observe" time blocks was tabulated and a total reactive value (RV) was obtained (McDaniel, 1978). The RV reflects the frequency of all of the categorized behaviors considered together. A high RV reflects a high frequency of stereotypic behaviors, averaged over all categories of behaviors and all sessions. Also, in order to isolate the effects of the four speeds of music on specific behaviors, the frequencies of Rocking, Idiosyncratic Stereotypic Behaviors, Vocalization, and Fidgeting were separately calculated for each speed.

Results

Table 1 presents the mean frequencies for the five categorized behaviors at the four levels of the rate manipulation (16, 35, 45, and 78 rpm). Figure 1 is a graphic display of these same data.

The graphic display of Figure 1 indicates that for Rocking, Vocalization, and Average Overall Reactive Values (RV), the anticipated bell-shaped function, with a peak at 45 rpm, is approximated. Idiosyncratic Stereotypic Behaviors show a very similar pattern, with the exception of a dip at 33 rpm. Fidgeting produces a somewhat displaced curve, peaking at an earlier (33 rpm) rate, while Rhythmic Behavior clearly has a unique function. It may be noted that Rhythmic Behavior is in fact unique relative to the other categories of behavior because, as defined, it is not a stereotypy that occurs independent of music, and it is not potentially maladaptive in the sense that the other behaviors are.

The statistical significance of the differences among the means of the four conditions of rhythmicity, as indicated by t-tests, are presented in Table 1. While the mean differences do not reach statistical significance, the global curvilinear trend across categorized behaviors that was predicted is evident graphically.

Table 1

	RPM			
	16	33	45	78
Rocking	$.67^{*}$	1.50	3.00^{x}	1.22
Idiosyncratic Stereotypic Behaviors	10.83	8.86	13.69	12.11
Vocalizations	$.72_{**}$	1.79	3.23^{x}	$.67^{**}$
Rhythmic Behaviors	1.67	$.86^{*}$	1.77	4.00^{x}
Fidgeting	4.72	6.07	4.46	3.89
Average Overall Reactive Value	3.72	3.81	5.23	4.83

Means with a * or ** designation differ from the means designated with ^{x} by $\underline{p} < .05$ and $\underline{p} < .01$, respectively.

Most pertinent from the standpoint of therapy, it is evident that some rates of rhythmicity are associated with high frequencies of stereotypy, while other are associated with low frequencies. Although the reductive effect of rate varied across categories, Figure 1 indicates that for all categories, there was at least one specific rate that was associated with a low frequency of stereotypy.

Discussion

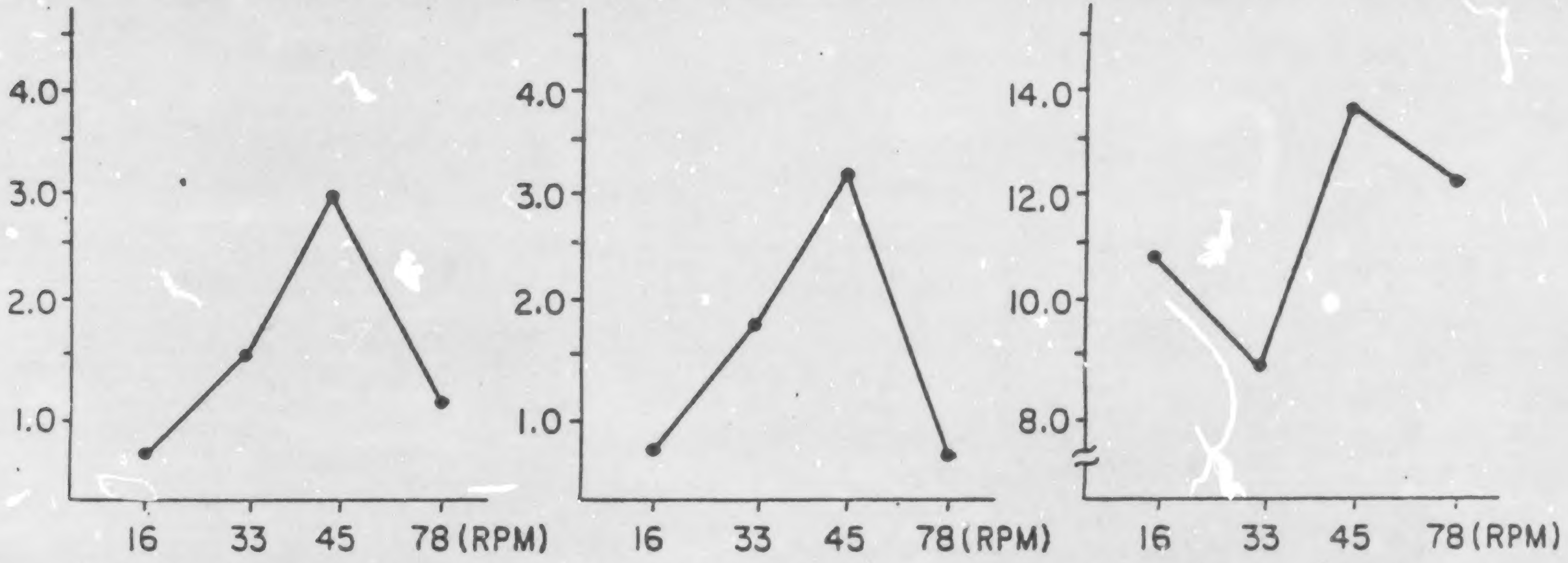
The present study's goal was to examine the effect of the rate of rhythmic auditory stimulation on the stereotypies of developmentally delayed children. Despite the fact that there were large individual differences in types of behaviors engaged in by the different children, there were significant mean differences between the conditions of rate of rhthmicity for specific behaviors, and consistent trends in the data were evident graphically.

The general trend exemplified in five of the six graphs in Figure 1 is an inverted u-shaped function. Thus, the rate of rhythmic auditory stimulation in the present study was positively related to general levels of behaviorsl stereotypies up to a certain rate; beyond that rate, there is a reversal of this effect. This effect is probably similar to the phenomenon that normal adults experience while listening to a soundtrack played at a high (78 rpm) speed, i.e., the music seems to lose rhythmicity because of its extreme rate.

Koegel and Covert (1972) have demonstrated that when children engage in stereotypies, they are effectively "tuned out" with respect to attending to the events in their surrounding. Specifically, Koegel and Covert demonstrated that abnormal children could be induced to engage in productive learning activities when their stereotypies were suppressed. Conversely, discrimination learning by the children of their study was greatly impaired when they engaged in stereotypic behaviors.

The suppression procedure used by Koegel and Covert (1972) consisted of a loud "No!" paired with a slap on the child's hand. Unfortunately, at least with some children, this procedure has the potential of evoking negative emotional behavior and resistiveness to the learning task that may itself have detrimental effects on learning (cf., Deckner, Deckner, & Blanton, in press). Non-punitive procedures that have the effect of reducing stereotypic behaviors may thus have applicability in a number of learning contexts. The present results suggest that providing abnormal children with music that has particular rhythmic characteristics has considerable promise in this regard. Furthermore, the present results suggest the importance of individualizing the intervention. More specifically, the most prudent course of action appears to be to determine empirically the particular rate of rhythmicity that is most effective in reducing a particular form of stereotypy.

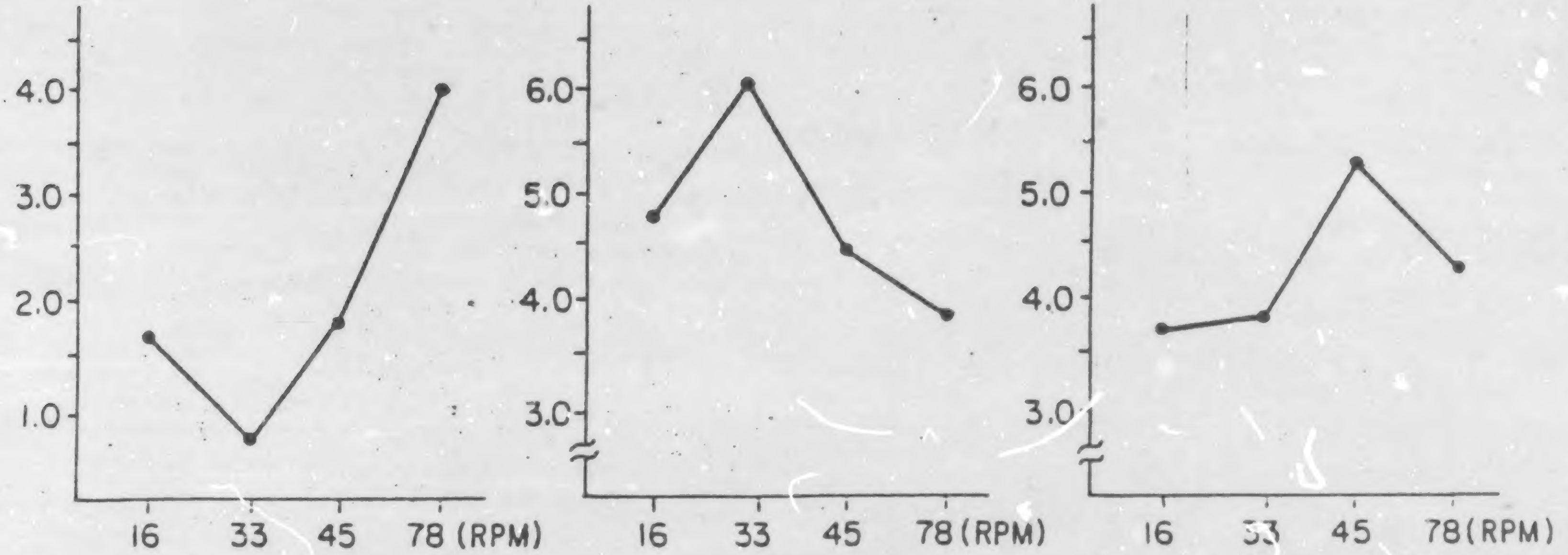
FIGURE 1



ROCKING

VOCALIZATIONS

IDIOSYCRATIC STEREOTYPIC BEHAVIORS



RHYTHMIC BEHAVIOR

FIDGETING

AVERAGE OVERALL REACTIVE VALUE

Intrinsic and Extrinsic Reinforcement Value and Sign Formations as Factors in the Sign Language Training of Austitic Children*

A number of recent studies have indicated that sign training might be a useful treatment procedure with autistic children, particularly when intensive speech training has failed to produce progress in the acquisition of speech or other communicative skills (Konstantareas, 1977; Schaffer & Goehl, 1974; Webster, McPherson, Sloman, Evans & Kerchar, 1973). The technique has also been employed with mentally retarded children with some degree of success (Bonvilion & Nelson, 1976; Creedon, 1973).

Until recently, little attention was given to structuring the communicative and linguistic environment of the autistic child. An impetus for the initial attempts to use sign language in the training of autistic and retarded children was, apparently, the success of such training with chimpanzees (Gardner & Gardner, 1969). However, the feasibility of such training might be deduced from the fact that hearing children of deaf parents frequently acquire signs as early as eight months of age and often have two sign utterances by the age of one year (Wilbur, 1976). While it might be assumed that this early learning of sign language by the children of deaf parents was due to the concentrated communication environment of the home, there does seem to be considerable evidence that all normal children can learn to communicate by signs at a very early age, usually several months before they acquire their first spoken words (Bates, Camioni & Volterra, 1975). This early development of signs may relate to the more rapid psychomotor development of the hand musculature, but it also suggests that all children may develop cognitive and semantic skills further in advance of their competance to produce spoken language than had been supposed (Wilbur, 1976). When we recall that the size, speed, and inertia of the motoric elements of spoken language involve rather critical temporal processing of intonational features in a tightly packed sequence, it is understandable that children with organic brain deficits, such as retarded or psychotic children, may have considerable difficulty in learning to produce such complex signals (Casey, 1978; Schopler & Reichler, 1971). Hand movements are, however, probably much easier for children to imitate and produce spontaneously (Wilbur, 1976). In this respect, it is worth noting that the motor skills in the area of hand and body movement are quite often normally developed in autistic children (Kanner, 1943). This is to some degree an anomaly, since in retarded children the psychomotor skills component is usually retarded as well as processes usually considered to be intellectual. However, mute autistic children are frequently observed to be able to execute fairly complex sequences of body movement and manual movement (Shapiro & Kapit, 1978). Given such considerations, it is therefore not surprising that successful efforts to teach autistic children to use simple signs have been reported in the literature, and such programs are apparently coming into existence in a number of training centers (Kopchick & Lloyd, 1976; Dxman, Konstantareas & Webster, in press). Given that this is the case, it would seem worthwhile to conduct studies of the structure of signs, that is, the morphological or psychomotor component of the signs, as well as the semantic content of signs to determine which signs are most easily learned by autistics and under what circumstances. The grading of learning tasks by difficulty level is an important component of educational technology.

*Data for this project was collected by Barbara Spaulding for an undergraduate honors thesis under the direction of R.L. Blanton

Skinner (1957) in his book, Verbal Behavior, divides words into two categories based on the reinforcement characteristics which they possess. These two categories he designates "mands," defined as words which designate gratifiers and which, when used by the speaker, communicate to the listener the wish for a gratifier; and "tacts," words which designate objects, which do not in themselves have any reinforcing characteristics although they may obtain such meanings through association with gratifying states of affairs. It is Skinner's view that language begins principally with mands, that is, the child learns to make his wishes or his needs known to the parents and the signs or words he uses to accomplish this purpose are quickly fixed in his repertory. Tacts, on the other hand, are acquired primarily through demonstration and instruction as a result of the process of acquiring an interesting language for its own sake which begins when the child has developed some communication facility and is able to acquire reinforcements from the process of speech itself.

Whereas spoken words may be classified as to the difficulty of pronounciation, especially involving the number of syllables as well as the occurrence of such properties as labial-dental fricatives which are difficult for a child to learn to produce, spoken words generally constitute a rather continuous array of difficulty levels. With respect to signs, however, it has been customary to classify signs in accordance with their use and imitative characteristics. For example, Wundt 1900), who did one of the earliest studies of signs in psychology, classified signs as "directing" (pointing signs, "copying" signs, which outline the object in some way, and "representative," those in which an object is depicted by selecting some property or characteristic. For example, the sign for "man" is made by the gesture of lifting a hat. Stokoe, in 1960, published a descriptive study of American Sign Language in which he classified signs in a similar way to those discussed by Wundt. These he called "pantonyinic," which are renactment signs used mainly for verbs, "imitative" signs in which an essential feature of the action or object is used to represent the whole, and "arbitrary," those in which a non-essential feature of the object is used, or in which an easily executable movement comes to be associated in an arbitrary way as a result of the designation by the users of the sign language as a term.

We have been unable to determine whether in the literature on the training of retarded and autistic children in sign language anyone has seen fit to grade or order the training task with regard to the learnability of the signs, in terms of their structural properties (that is, the psychomotor skill required), or to determine the learnability of signs as a function of their reinforcing properties. In the following study, we decided to use imitative signs, half of which had mand and half of which had tact classifications, and arbitrary signs, half of which had mand and half tact classifications. Our assumptions are that because of their greater motivational value, mands will be learned more rapidly than tacts, but that imitative signs will be learned more rapidly than arbitrary signs. We would therefore expect that the easiest signs to learn would be imitative mands. For example, the American Sign Language sign for "eat" is made by bringing the hand up to the mouth in a gesture closely resembling the act of eating, thus it imitates a mand type function.

A variable which may prove to be of some significance in the training of autistic children in sign is, of course, the difficulty of executing the sign, that is, the psychomotor skill required. This appears to be, to a considerable extent, a function of the child's ability to perceive the sign as a whole when it is modeled by an instructor. American Sign Language, as used by the deaf population, tends to be quite exact and signs, especially those used by speakers on a platform, are very carefully and exactly made so as to lead to no errors in interpretation. Hence the position of the hand with regard to the body, the orientation of the hand, whether the arm is rotated or prone or supine, the positioning of the fingers in the execution of the sign, all are important features and must be carried out reasonably exactly in order to be accepted as a correct sign. In the training of autistic children, of course, it will be necessary in the beginning to accept approximations on the attempts of the child and to reinforce these efforts in order to gradually shape the correct execution of the sign in such a way as to make it possible for other observers to interpret the sign without error. Hence the training of the experimentor in the interpretation of the child's skill in the execution of the sign is a problem since criteria of acceptability would tend to become more rigorous over the training period and the reliability of judgment of acceptability may be a problem in the scoring of the child's achievement.

Method

Design

A latin square, single subject design was used in order to counterbalance for the effects of the order of signs in training. The study was designed to investigate the characteristic of the word (mand vs. tact) in comparison to the topography of the sign (imitative vs. arbitrary). The following signs were chosen for training and selected on the basis of sign topography and word characteristic: imitative mand: eat, arbitrary mand: drink, imitative tact: first set: book, second set: ball, and arbitrary tact: shoe. Finally, two trainers worked in alternating training sessions in order to control for possible experimenter bias.

Subjects

The subjects were four male children, ages eight, 10, 11, and 13, drawn from the residential population at Walden House.

Subject Selection.

Of the Walden House population, children were eliminated from consideration to serve as subjects by the following criteria: if they were scheduled to participate in a signing program within the curriculum of Walden House; if they were considered to be so low functioning as to be incapable of learning signs at the present time; or if they had relatively high verbal ability and the teaching of signs was therefore considered unnecessary by the Program Director. Of the remaining subject pool, four children were selected who had some receptive language abilities and sufficient manual dexterity to be considered capable of learning the motor movements inherent in the sign language training. In addition, subjects were initially judged comparable from reports by staff technicians and the Program Manager.

Pretest Measures.

To further insure that each of the four subjects would be amendable to sign language training, several measures were taken prior to the onset of training. The scores received by each of the four subjects on the Catell Infant Intelligence Scale in 1976 (in terms of intelligence quotient and mental age), and the age equivalent and social scores received on the Vineland Social Maturity Scale are shown in Table 1.

Table 1

Scores Received by Subjects on the Catell Infant Intelligence Scale and the Vineland Social Maturity Scale

Catell Infant Intelligence Scale

Subject	Age at Testing	MA	IQ
1	11-11	1-11	17
2	6-8	1-7	23
3	9-8	1-6	15
4	8-1	1-3	15

Vineland Social Maturity Scale

Subject	Age at Testing	Age Equiv.	Social Quotient
1	11-11	4.5	.375
2	6-8	1.8	.271
3	9-8	1.9	.194
4	8-1	2.2	.272

NOTE: These scores were determined in 1976 and may have changed slightly since that time.

Mental age for each subject was further assessed in 1978 by the Peabody Picture Vocabulary Test.

Table 2

Scores Received on the Peabody Picture Vocabulary Test and Communication Abilities

Subject	Age at Testing	MA	Communication Abilities
1	13-11	1-9	Mute; some pointing behavior
2	8-8	1-11	Some imitative language, simple words, poorly articulated
3	11-8	2-1	Mute, 4 signs previously learned
4	10-1	1-9	Some verbalizing, no understandable words

NOTE: Testing date: 11-78.

Also shown in Table 2 are the communication abilities of each of the four subjects at the time of testing. In addition, three informal baseline measures were taken at this time. All were 10-minute sessions with 100% reliability. First, each child was assessed as to his ability to imitate various components of the signs to be taught. These included the motoric acts of making fists, clapping, hand to mouth, hands over head, and knee to knee (a left to right motion across the body). The results of this test are shown in figure 1. The second informal measure was designed to assess the child's verbal receptivity on the four stimulus words to be used.

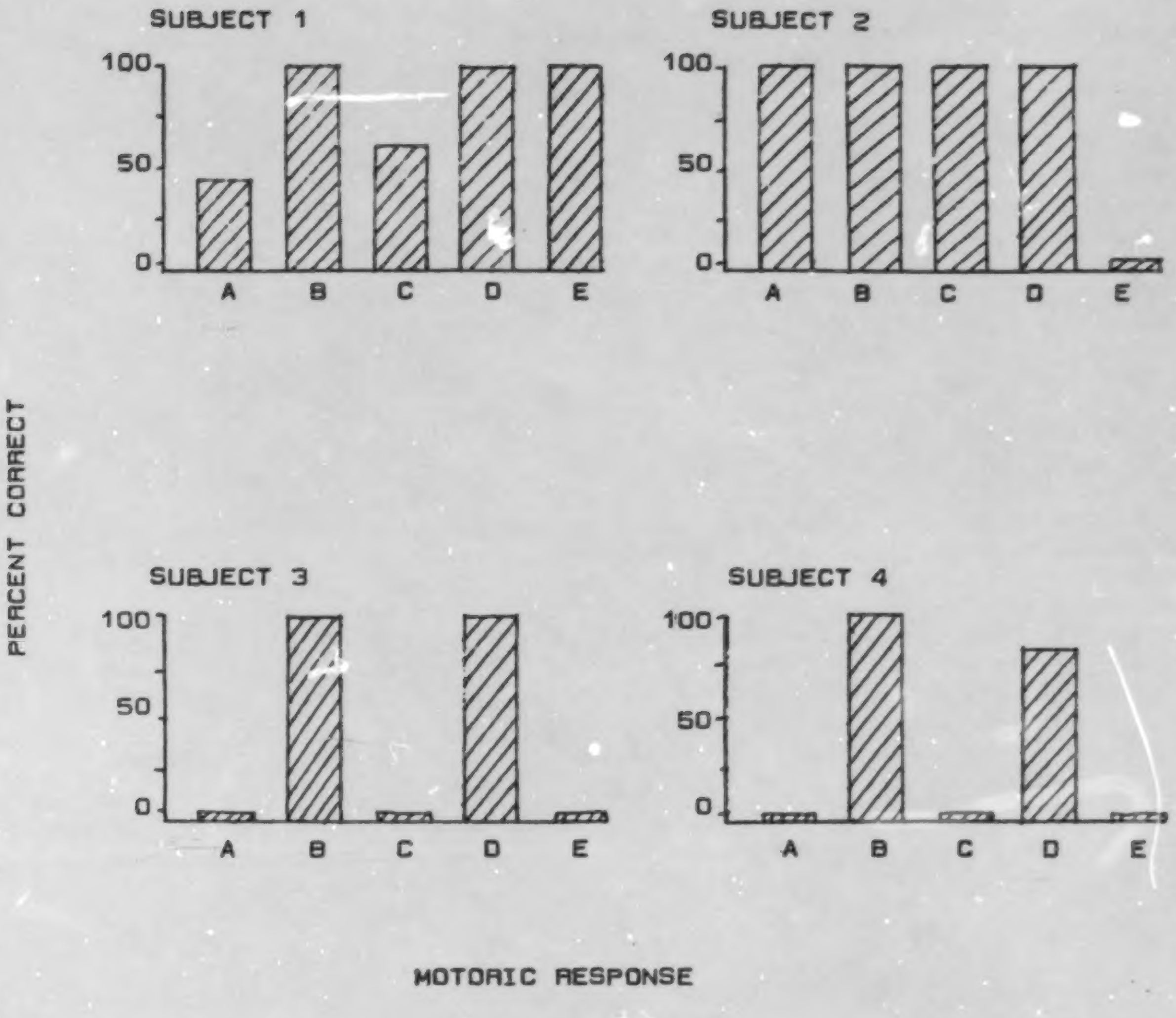


Fig. 1. Percentage of correct responses made by four autistic children on Imitative Pretest (motoric components of the signs to be trained). A (make fists); B (clap); C (hand to mouth); D (hands over head); E (knee to knee).

The trainer placed the four stimuli in front of the child and spoke the stimulus word, expecting the child to respond by handing the trainer the appropriate object (See Figure 2). The third measure was a test of sign receptivity; the experimenter made only the signs for each of the four stimuli to which the child was to respond by handing the experimenter the appropriate object. The results of this measure may be seen in Figure 3.

Setting

The experimental sessions took place at Walden House in Nashville, Tennessee. Sessions one through 24 were conducted in an unused room at Walden House in which there was an outside window and two beds in addition to the furniture used in the training session (two chairs, a table on which the stimuli and reinforcers were placed, and chairs for the raters). Sessions 24 through 44 were conducted in a smaller, less distracting lab room containing only the furniture used for the training sessions.

Materials

The stimuli to be presented in the training sessions included shoes, book, balls, and various types of food and drink. To insure that the subject did not fixate upon one particular stimulus item, the specific item was randomly changed from time to time. The correct representation for each of the trained signs (eat, drink, book, shoe, ball) are presented in Appendix A.

Procedure

The Training Sequence

Each subject participated in two 15-minute training sessions per day for a total of 10 sessions per week.

During each session, the trainer sat facing the subject with the child's legs placed between the trainer's legs for maximum behavior control. The trainer gained eye contact and stated the child's name at the beginning of each trial. Next a given stimulus item was presented multi-modally, that is, the item was simultaneously presented visually as well as auditorily (the trainer spoke the stimulus word to the child). Within any single "trial," the subject had two opportunities in which he might receive reinforcement for an acceptable response. If the child made a rewardable response after the stimulus was initially given, he was rewarded and a new trial was begun. However, if the child's response was unacceptable, the trainer aided the child via modeling or prompting the desired response. Regardless of the outcome of the second response, a new trial was subsequently begun.

Criteria for initiating a new sign in training.

1. As the subjects began to make increasingly better approximations of the signs as a result of the shaping procedure, the experimenters established more stringent requirements on the children as to the level of acceptability for a given response to receive reinforcement. In view of this confounding effect, we utilized a mean criterion level of 75% correct responses over a majority of the previous trials in conjunction with the judgment of two raters in determining whether the child was ready to learn a new sign. As training on newly initiated signs proceeded, the subjects were tested on the retention of previously learned signs. The test trials were fewer in number than the training trials and were interspersed within the session to insure correct discrimination between signs. Hence the acquisition rates of all signs in training were maintained if not improved over time.

2. By session 18, it became apparent that by requiring the subjects to make exact imitations of all the various signs, we were actually beginning to extinguish a functional representation of these signs. At this time, we began to accept such functional representations (which had been previously regarded as approximations) as correct, and rewarded them as such.

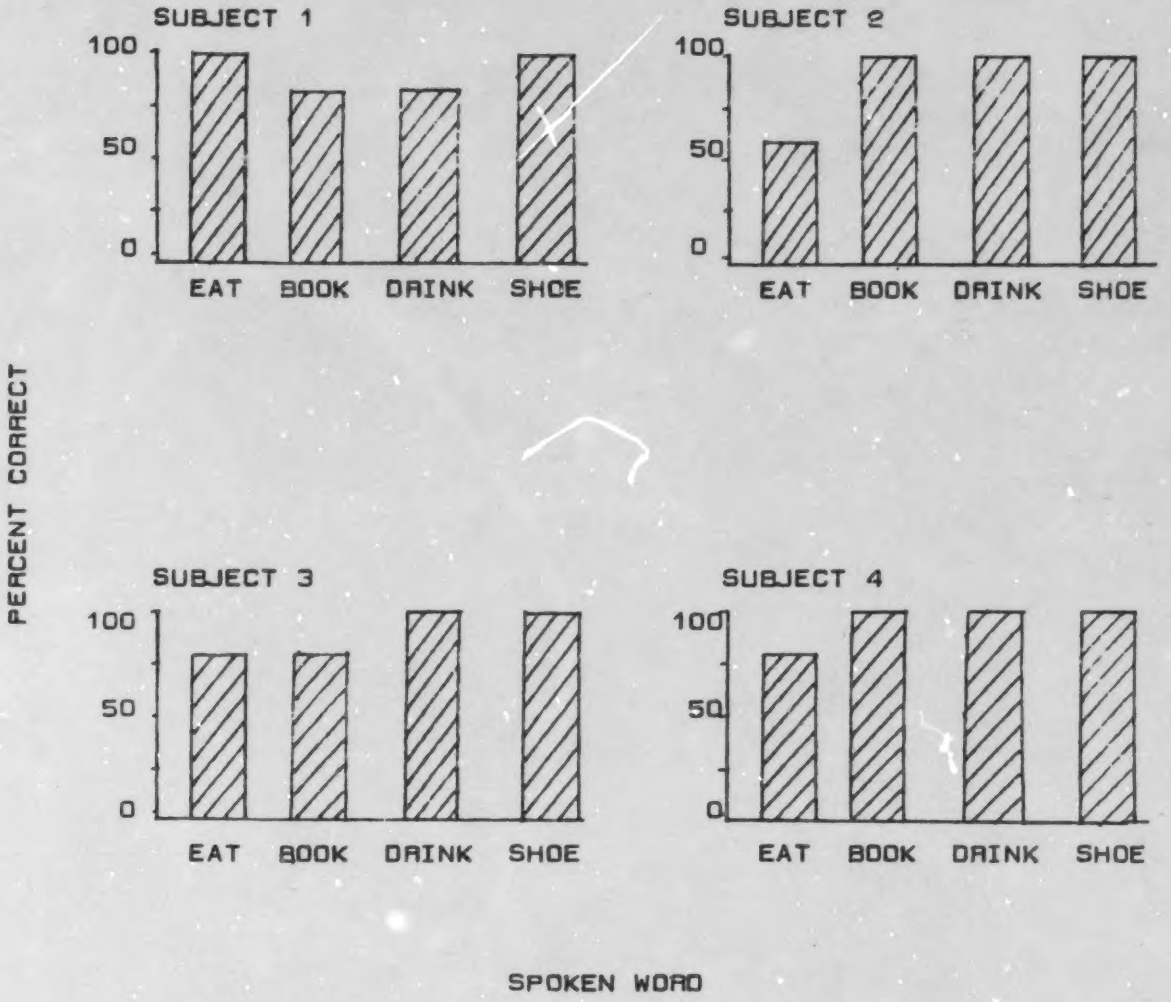
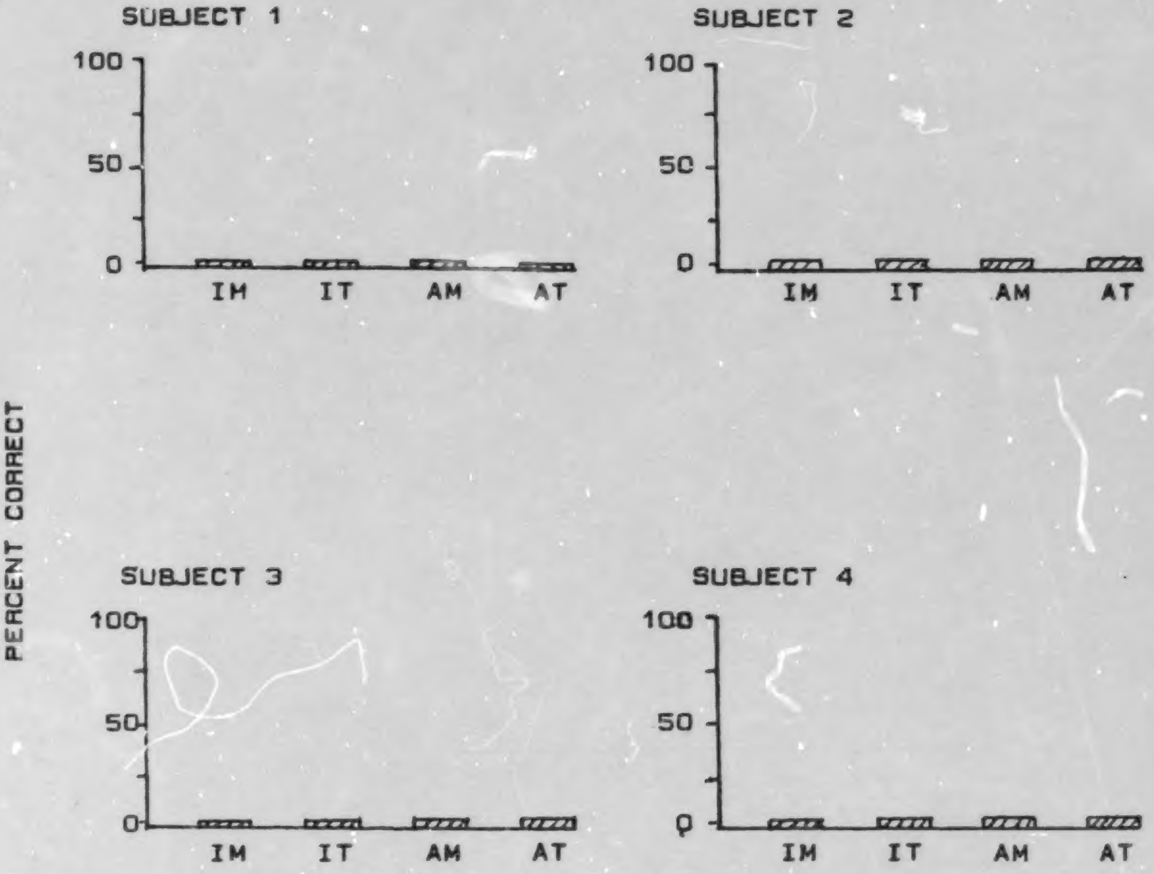


Fig. 2. Percentage of correct responses made by four autistic children on Verbal Receptivity for the four stimulus words: eat, book, drink, and shoe.



SIGN CHARACTERISTICS

Fig. 3. Percentage of correct responses made by four autistic children on Sign Receptivity Pretest. IM (Imitative Mand): Eat; IT (Imitative Tact): Book; AM (Arbitrary Mand): Drink; AT (Arbitrary Tact): Ball.

Reinforcement Techniques

The subject received both tangible and social reinforcement each time he elicited an appropriate response to a given stimulus item. For those signs which were categorized as mands (be they imitative or arbitrary in topography), the child was rewarded with the appropriate stimulus item. That is, for an acceptable response to the stimulus "eat" or "drink," the child received some type of food or liquid reinforcement, respectively. In the case of tacts, the subject's response (again, regardless of the imitative or arbitrary aspect of the sign) was non-discriminately rewarded with a variety of reinforcers, both food and drink. Care was taken not to use food reinforcers commonly utilized by the Walden House staff in order to increase the value of the tangible reinforcement for the subjects.

Scoring

Prior to the beginning of the experimental sessions, all raters underwent two separate training conditions.

Phase I. Raters were first trained with respect to the rating system used for the study. Responses made by the child could be scored as rewarded or unrewarded corrects, rewarded or unrewarded approximations, incorrects, or no response. In like manner, the following prompting techniques utilized by the trainer in shaping the desired responses were also to be recorded: modeling, in which the trainer performed the correct response for the child to imitate; full physical prompting, in which the trainer physically manipulated the subject's hands through the entire response movement; and partial prompting, in which the trainer gave some cue to the child to either elicit an initial response or to influence the occurrence of a part of the sign. This method of recording the training procedure reveals the temporal sequence of the session.

Phase II. The second phase of training for the raters involved the four children who were under obligation to Walden House to record the occurrence of inappropriate behaviors and administer the appropriate contingencies specific to each child, the raters were trained to recognize the various behavioral characteristics for each child. This phase of training also served to get the children accustomed to the presence of one to three raters in the room prior to the start of actual training.

Reliability

Reliability ratings were taken for eight of the 10 training sessions each week. The remaining two sessions were recorded by the trainer. Over time, the two experimenters found that five of the eight raters achieved consistent agreement between themselves as well as with data collected by the trainers. Spot checks of reliability were taken across time between these raters and revealed the following reliability ratings: Session 7: 98.2%; Session 24: 100%; and Session 30: 95.7%

Results

Subjects 3 and 4 were discontinued after Sessions 34 and 35, respectively, as their acquisition of the signs was so slow as to prevent them from learning the four signs inherent in the experimental design within our given time constraint. A primary reason for their delayed acquisition is believed to be the excess of inappropriate behavior (self-stimulatory behavior and inattention) exhibited by these children during the training sessions. The sign acquisition patterns of these two children are shown in Figure 4. The reader will also note the oscillatory pattern of the learning curves exhibited by Subjects 3 and 4, which is believed to be typical of autistic children (Lovaas, 1977).

Table 3 shows the number of trials and sessions needed by each of the remaining two subjects to acquire the sign for a single item or to discriminate between several items.

Table 3

Number of Training Trials vs. Training Sessions to Reach Criterion Run for the Five Stimulus Items*

Training Order	Child 1		Child 2	
	Trials	Sessions	Trials	Sessions
First Item	[IT] 164	4	[AT] 1430	33
Two-way Discrimination	[IT+AM] 820	13	[AT+IT] 464	9
Three-way Discrimination	[IT+AM+IM] 122	3	[AT+IT+IM] 161	3
Four-way Discrimination	[IT+AM+IM+AT] 488	9	———	
Five-way Discrimination	[IT+AM+IM+AT+IT^2] 162	3	———	
TOTAL TRIALS	1756		2055	
TOTAL SESSIONS		34		45

IM: Imitative Mand [Eat]
AM: Arbitrary Mand [Drink]

IT: Imitative Tact [Book]
AT: Arbitrary Tact [Shoe]
IT^2: Imitative Tact [Ball]

NOTE. Child 1, Total Trials and Sessions through the Three-way Discrimination level equal 1106 and 20, respectively.

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*The design for this table follows that presented by Carr, Binkoff, Kologinsky & Eddy [1978].

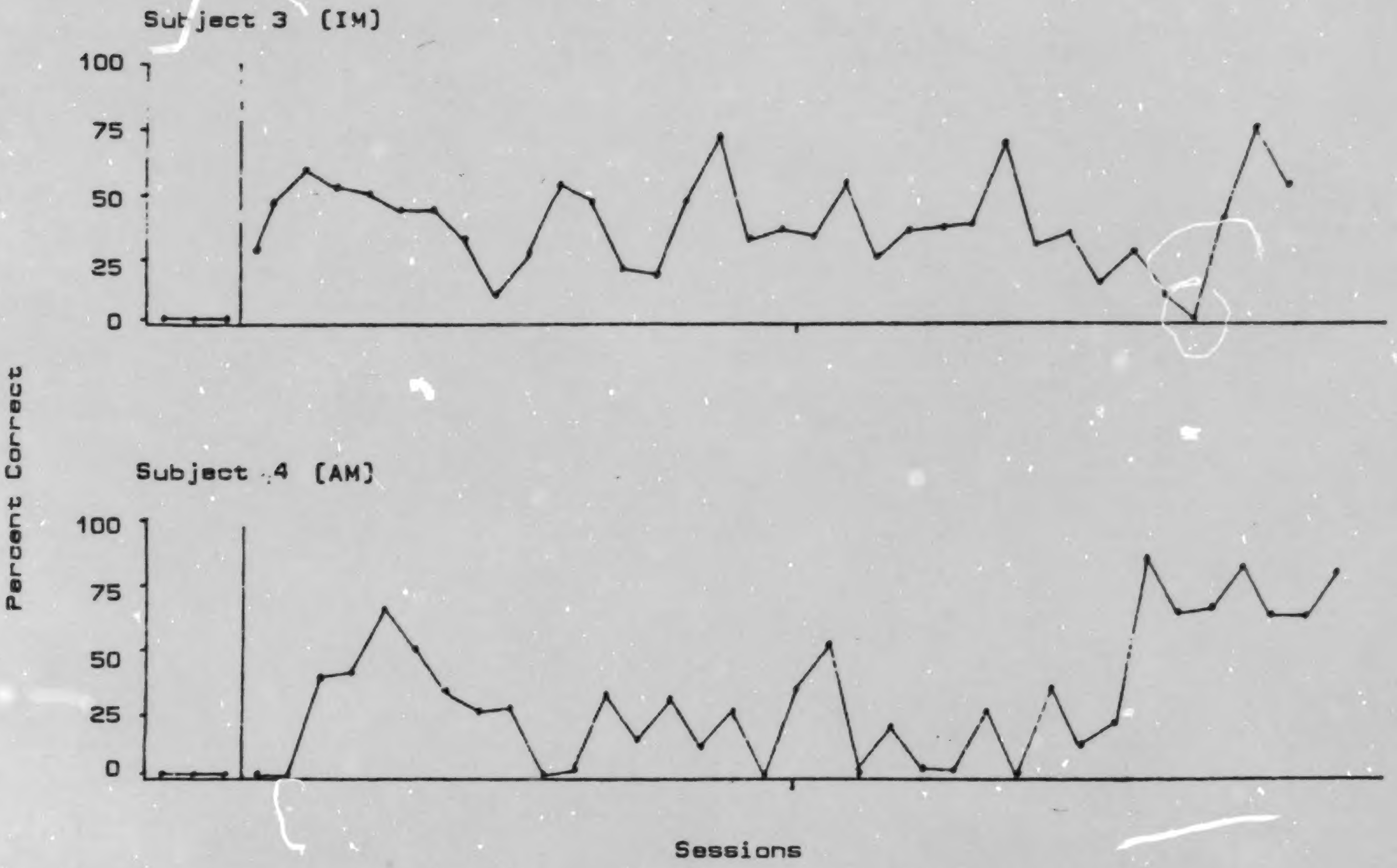


Fig. 4. Percentage of correct responses made by Subjects 3 and 4 on the Imitative Mand (IM, "eat") and Arbitrary Mand (AM, "drink") signs, respectively. The solid line indicates the end of the baseline period.

Since the order of presentation (training) of the signs was counterbalanced among the subjects, Table 3 also lists, in parentheses, the characteristics of the sign or signs being trained or maintained. The last sign listed denotes the sign currently under training. The criterion level to be reached before initiating training on a new sign was a mean of 75% rewarded corrects on the sign currently under training over the last three sessions or a majority of the preceding sessions (for example, three of the preceding four sessions). As can be seen, the number of both sessions and trials tends to vary according to the imitative characteristic of the sign, regardless of the mand/tact characteristic across both children. This is despite the fact that a comparison of the two subjects at the level of three-way discrimination reveals that Subject 1 was learning the signs at approximately twice the rate of Subject 2. However, analysis of these data reveals that Subject 2 exhibits some transfer effects whereas Subject 2 exhibited a high rate of correct responding from the onset of training. Finally, correct discrimination between stimulus items was demonstrated over training sessions by both subjects.

Figure 5 shows the percentage of correct responses for each sign made by the children in the initial session of training. For each given sign category, the abscissa denotes subjects and the ordinate, percentage correct in the first training session. Each child displayed 0% correct prior to training. As Figure 5 indicates, across children, those signs with imitative characteristics consistently show an initially higher percentage of correct responses than those signs with arbitrary topography, regardless of the mand/tact characteristic. In addition, the percentage of correct responses made by Subjects 3 and 4 (29% and 0%, respectively) are significantly lower than those made by the other subjects within the same sign categories.

The learning curves for Subjects 1 and 2 are plotted in Figure 6. As previously mentioned, the criteria for that which constituted a correct response changed at Session 18 from the exact imitation of a given sign to a functional representation of that sign, and the learning curves for each of the children reflect this change. In addition, the second line to the right on each of the graphs represents a two-month period in which no sign training occurred. The reader will notice that for both subjects the correct response level for each previously trained sign was higher than the initial response level for that sign. This suggests that the subjects did retain skills from the previous training. More importantly, however, the percentage of correct responses was significantly higher for those signs with imitative topography than for those signs with arbitrary topography across children (see Figure 7).

Finally, inherent in the training procedure used with each subject to shape desired responses was the necessity to initially reward approximations for the given stimuli. As the child's responses improved, the criteria for him to receive a reward became more stringent. Thus, these criteria shifted somewhat arbitrarily according to the child's improvement in imitating the desired response. Given these considerations, the criteria for what constituted a desired response would also change arbitrarily over time and the data may therefore be somewhat more difficult to interpret. For these reasons, the percentage of rewarded approximations for Subjects 1 and 2 may be seen in Figure 8. In each case, there exists an inverse relationship between rewarded corrects and rewarded approximations. Thus as the child improved throughout training, the incidence of rewarded approximations decreased accordingly.

Discussion

The children serving as subjects in the present study had failed to acquire

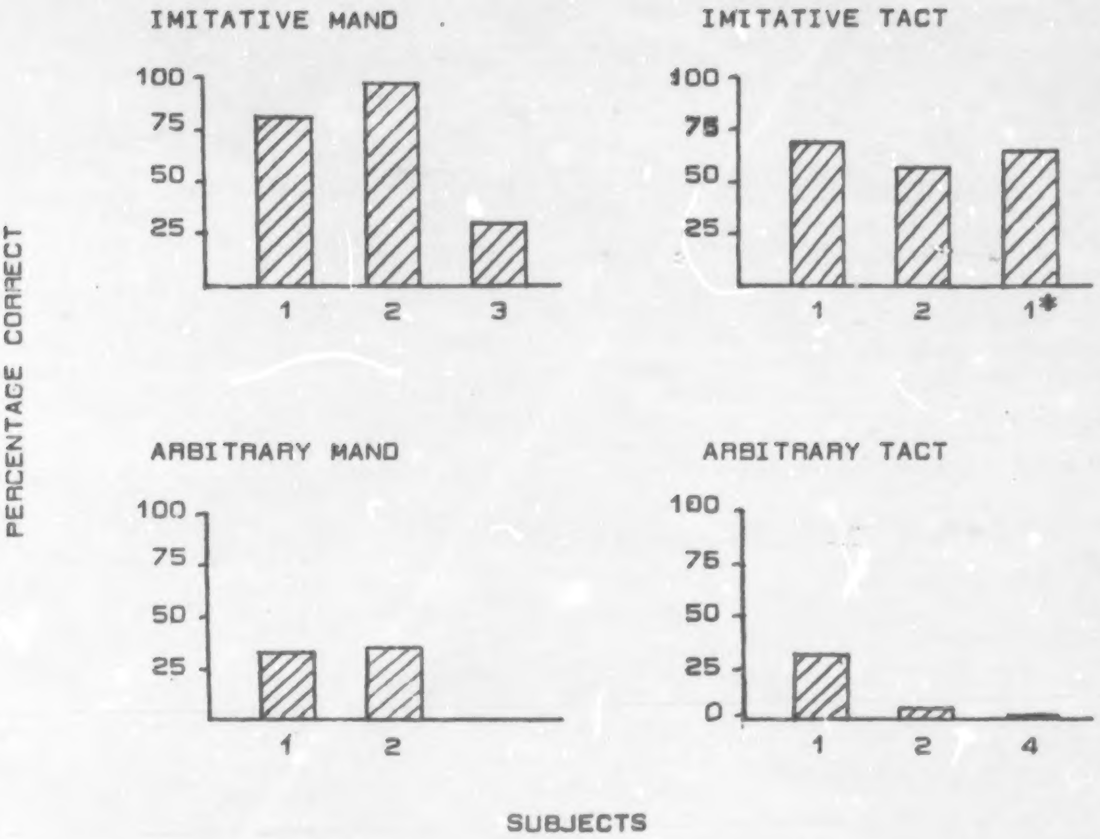


Fig. 5. Percentage of correct responses made by autistic children in the initial training session for each of the sign categories.

*Subject 1 began the second sequence of sign training with an imitative tact.

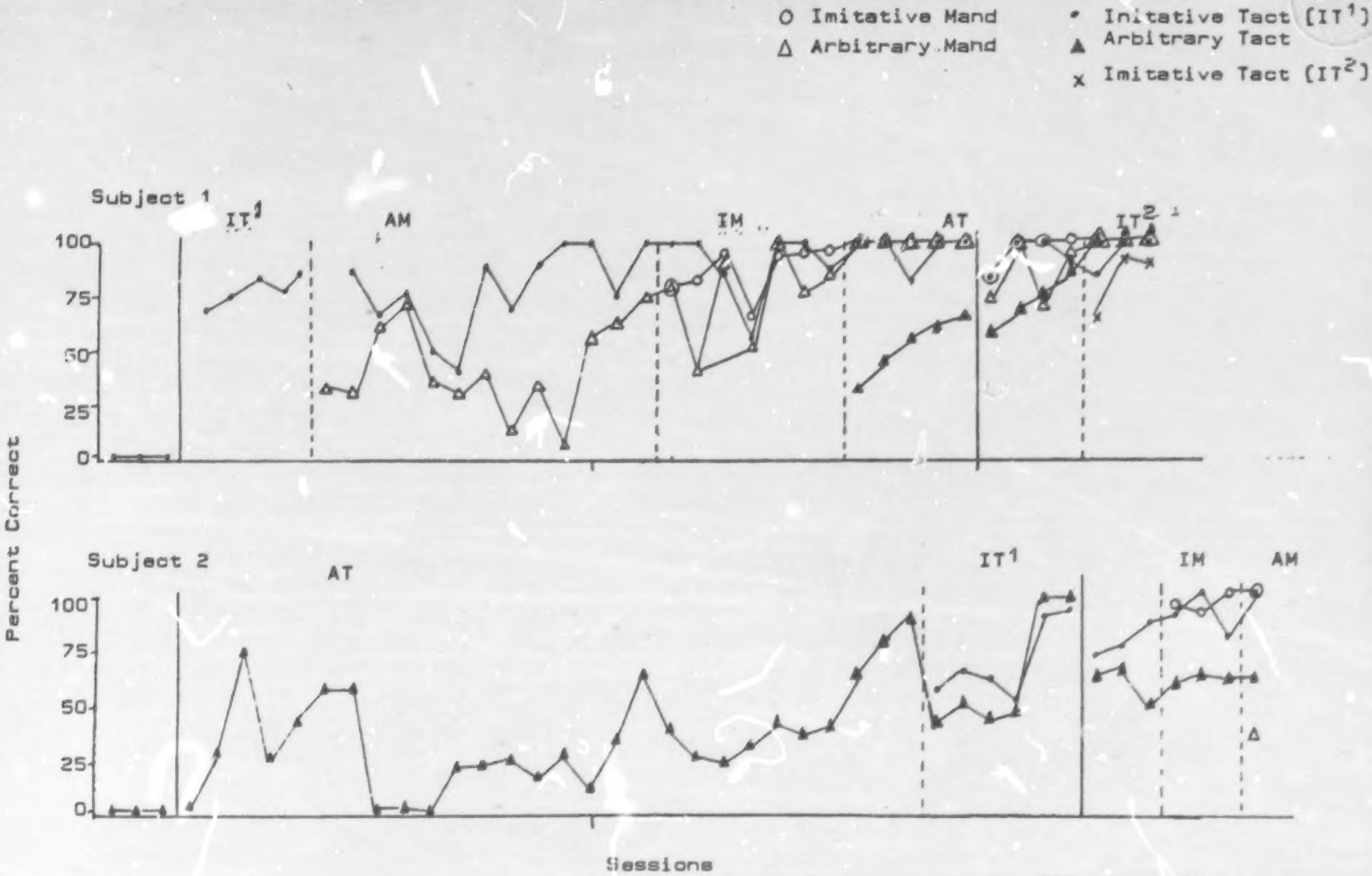


Fig. 6. Percentage of rewarded correct responses made by two autistic children. The hashed lines represent the introduction of a new sign. The first solid line represents the end of baseline, which for all children across all signs, remained at 0. The second solid line indicates the two-month period of no training.

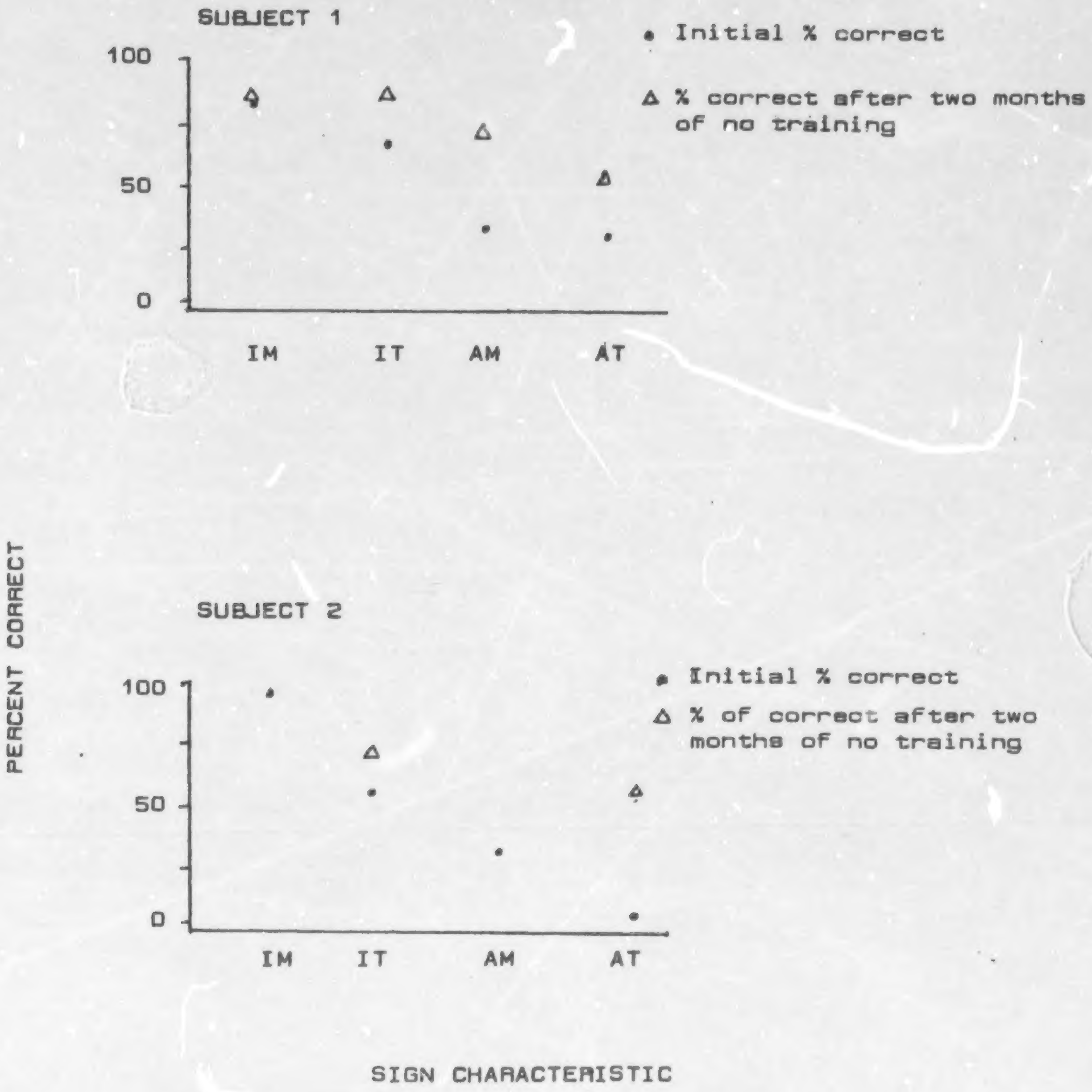


Fig. 7. A comparison of correct responses between first training session and Session 40, when sessions were resumed after a two-month period of no training.

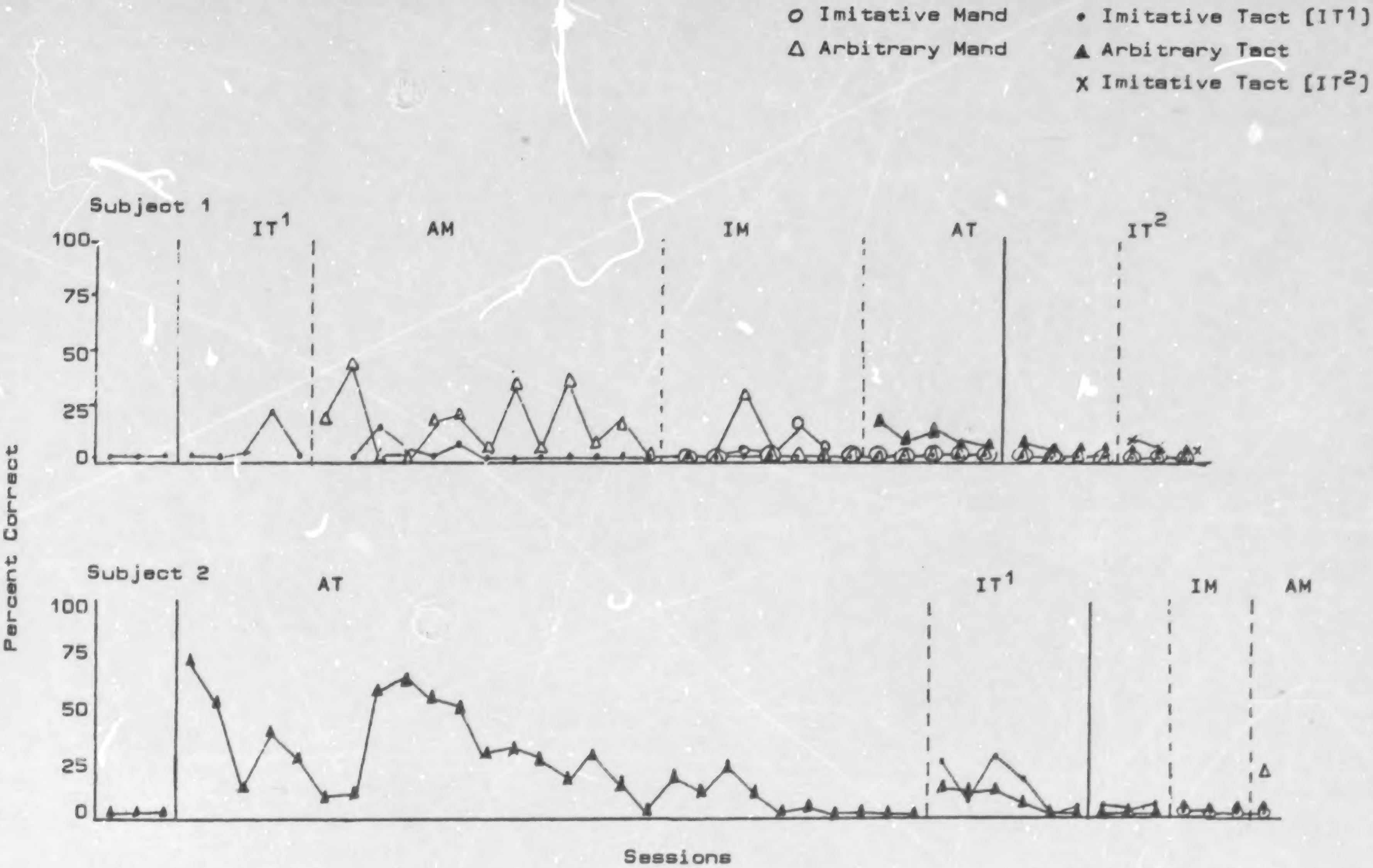


Fig. 8. Percentage of rewarded approximations made by two autistic children. The hashed lines represent the introduction of a new sign. The first solid line represents represents the end of baseline, which for all children across all signs, remained at 0. The second solid line indicates the two month period of no training.

effective verbal communication skills despite a number of treatment efforts. Such children, according to Rutter (1966) have a poor prognosis and "are regarded as having no potential for developing a system of communication" (Carr, et al., 1978). The fact that these children did acquire multiple sign discriminations lends support to the effectiveness of simultaneous communication training and shaping procedures as appropriate intervention strategies for low-functioning autistic children. More importantly, however, is the fact that both children consistently acquired those signs with imitative characteristics more readily than those with arbitrary topographies. In addition, as Table 3 and Figure 5 both indicate, the imitative aspect supercedes the mand/tact characteristics of the words across signs and children. Finally, the fact that both the initial response levels and retained response levels after a two-month period of no training reveals the same hierarchical pattern of acquisition further supports our hypothesis that imitative signs are more readily learned than arbitrary signs.

Few studies to date have indicated that autistic children can successfully discriminate between objects in their environment using signs. Carr and his colleagues (1978) demonstrated this fact, however they did not identify those variables which may plan an important role in discrimination learning. In his study, Carr studied the acquisition of expressive sign labels across five nonverbal autistic children. The signs trained in their study were all food items, that is, mands. Carr found that although his subjects needed relatively few trials to acquire the first sign in training, the acquisition of subsequent signs required many more trials. This he attributes to the increasingly more complex discriminations the child must make as he learns new signs. In contrast, Wilbur (1976) cites a number of studies using the same training procedures with the same population which concluded that as new signs were introduced, fewer and fewer repetitions were required for each successive sign. In fact, she states that "one child acquired signs so rapidly that it was difficult to consider him retarded" (p. 488). The results of the present study, however, seem to indicate a controlling variable in the acquisition of and discrimination between signs by the autistic population which may account for the conflicting reports of Wilbur and Carr. An examination of Table 3 reveals that across both children, the imitative characteristic of the sign being trained directly influenced the number of trials necessary for learning the criterion, regardless of the number of discriminations involved. The fact that Carr and his colleagues did not classify their training signs according to topography (four of the five mand-type signs used had arbitrary topographies) may account for their conclusion that acquisition time was dependent upon the number of discriminations involved.

These results do not, however, invalidate the role of extrinsic vs. intrinsic reinforcement in the acquisition of sign language. We hypothesize that while the reinforcing qualities of signs have some influence on discrimination learning, they may play a more important role in the generalization and spontaneous usage of signs. That is, mands, which are intrinsically reinforcing, possess greater motivational value simply because they satisfy needs. Baron (1976) has proposed that language learning is largely motivated by the general survival value inherent in the acquisition of efficient communication. Indeed, for language to be functional, it must have the power to permit manipulation and modification of one's environment (Cromer, 1974). In the present study, we assumed that if the child was simply asking ("manding") for reinforcers during training, we would expect a lack of discrimination between stimulus items, particularly those designated as tacts. If the child correctly discriminated between the signs for "book" and "shoe," he would respond appropriately, thus demonstrating he was learning the tacts. As Table 3 suggests, both subjects were eventually able to correctly discriminate between a number of signs, regardless of their characteristics. However, on the few occasions when the subject responded to a given stimulus incorrectly, these errors were confined to a confusion between the tacts.

Discrimination learning is even more important within the context of the child's natural environment, where his newly-trained skills may potentially gain greater function and meaning. In the present study, both Subjects 1 and 2 spontaneously signed only for the mand related items during the training sessions; in each case, the child would sign for the type of reinforcer he desired. In addition, reports of Walden House technicians indicate that during the two-month recess from training, Subject 1 spontaneously signed for food and drink within his natural environment though he never used signs for tact classifications (Subject 2 had not yet received training on the signs with mand characteristics). It must be noted, however, that the children logically would have more opportunities to sign and receive immediate reinforcement for food and drink, as books, shoes, and balls are neither readily available nor desired by the children. Lovaas (1977) states that one cannot expect the behavior elicited under experimental conditions to generalize significantly unless one can ensure that the child is handled similarly in the different contexts in which he lives. If those in the child's environment continue to respond to the pre-existing communication patterns, there is no need for new learning ever to be demonstrated. In the present study, constraints of the setting prevented us from incorporating reliable generalization training or data collecting. The fact that some generalization of mand-type signs did occur under such intermittent reinforcing conditions is, nevertheless, noteworthy. Although there is not sufficient replication of these finding in our study, the observation of such differences between the two classes of signs certainly merits further investigative attention.

We believe that the imitative or pantonymic quality of signs thus appears to exert a more powerful influence than reward value. This suggests that the recognition value of a sign (like that for "book") is vivid enough in cognitive characteristics to lead to a ready imitation. Our results concur with cognitive theories of learning; that while reinforcement is important in learning, its primary importance lies in establishing a response that can easily be shaped and generalized to other settings.

The significance of our data gives rise to an important theoretical question with regard to the ability of imitative signs to generalize to abstract usage. Wundt (1900) suggests that perception is affected by those features of an object which make the strongest impression on his attention. Thus, it appears that imitative signs have features which strongly attention and perception and therefore dominate the formation of concepts. Wundt also believed that gestural language was more universal than spoken language because "signs have a closer and more natural relationship to their meaning than spoken words" (Blanton and Brooks, 1978, p. 246). This notion is particularly evident in those signs we call iconic (or imitative), paralleled in spoken language only by onomatopoeic words. According to Saussure, for all other spoken language, meaning is assigned arbitrarily (DuFrenne, 1963). While iconic representations may be more universal and may therefore lend themselves more readily to acquisition, the iconic meaning of signs may actually impede motivation for abstract usage (Tervoort, 1961). For example, the child who has learned the sign for "eat" under the training conditions of the present study may have considerable difficulty generalizing that sign usage to more abstract meanings (for instance, "Acid 'eats' through metal"). Klima and Bellugi (1975) attack this notion, stating that signs do have abstract, separable elements which, in isolation, are not considered meaningful. Klima and Bellugi base their argument on the fact that arbitrary signs do exist which have derived meaning from agreement among their users. They cite instances of poetry and metaphor in sign in an effort to substantiate their hypothesis; however, they do not distinguish in their research whether the signs in poetry were imitative or arbitrary in topography. The conflicting theories of Tervoort and Klima and Bellugi pose an interesting question for future research; that is, to what degree iconic vs. arbitrary signs may be generalized in meaning. The answer to this question may directly effect the direction of training procedures in manual communication with handicapped populations.

For the present, however, the utility of sign language training with autistic and retarded populations has been well substantiated. First, the successful sign training of apes (Premach, 1972; Premach, 1974) and exceptional populations (Carr, et al, 1978; Casey, 1978) indicates that sign is easier to learn than oral speech, as speech requires relatively advanced development of auditory processing (Blanton & Brooks, 1978; Shopler & Reicher, 1971). In addition, the fact that visual discrimination skills develop earlier than auditory discrimination skills and signs are motorically simpler than speech making gives further credence to the use of signs by low-functioning populations (Wilbur, 1976). Signs are especially valuable instructional tools for autistic children because they are visual stimuli which many autistic children may attend to with greater ease, particularly in light of their poor auditory processing skills (Oxman, et al., in press; Wilbur, 1976). Second, the oralist's belief that signing impedes the acquisition of speech has been disreputed. Signing has been shown to actually facilitate speech. Thus, oral language and speech may be effectively built in through a functional communication system using manual signs (Bricker, 1972; Shaeffer, B., Kollinzas, G., Musil, A., & McDowell, P., 1977). Finally, the implications of the present study are two-fold. First, our findings lend further support to the utility of sign language training with autistic populations. Second, and more importantly, the fact that differences between classes of signs were observed raises important issues for future investigation which may have significant effects upon the development of more effective sign language training procedures in the treatment of childhood autism.

Preattention and Attention in Developmentally Delayed Children

Etzel, LeBlanc, Schilmoeller, and Stella (1981) suggest that the first question that should be asked about the conceptual training of young children concerns preattention. Preattending may be defined as a series of behaviors that lead to the reception of appropriate stimuli on the subject's sensorium, such as the orientation of the head and eyes toward the critical stimuli. The subject learns to look at one aspect of the environment rather than another because that initial preparatory response is followed by a final response in the chain that ends in reinforcement (Etzel et al., 1981; Trabasso, Bower, Gelman, & Schaeffer, 1966). Etzel et al. (1981) thus suggest that a useful distinction can be made between preattending behavior (i.e., the preparatory responses defined above), and "attention" which they define as the establishment of the specific stimulus-response relationship that is the ultimate objective of training.

The present study investigated the utility of a technique designed to establish preattending behavior. Preattending behavior is a prerequisite to children's using auditory cues in making visual discriminations. Preattending training thus also could be important in a number of educational contexts, e.g., in teaching object/name correspondence and in teaching reading. Several lines of converging evidence and theory have led a number of investigators to postulate that reading comprehension evolves from the previous learning of auditory-visual equivalences (Birch, 1962; Sidman, 1971; Wepman, 1962). Sidman (1971) and Sidman and Cresson (1973) demonstrated with retarded children that learned auditory-visual equivalencies are prerequisites for the emergence of reading comprehension. Etzel et al.'s (1981) distinction between preattention and attention has support in the animal literature; e.g., Spence's discussions concerning "receptor-orienting acts" (Spence, 1937, 1940; also see Trabasso, Bower, Gelman, & Schaeffer, 1966). However, there is some question as to whether this distinction is important from the standpoint of educational intervention. Specifically, are there interventions that consistently establish preattending behavior, but do not concomitantly establish attending behavior? Without empirical demonstration of this particular conjunction of outcomes, Etzel et al.'s logically persuasive distinction becomes meaningless from the standpoint of practical educational concerns.

The practical implication of Etzel et al.'s (1981) distinction is that some children may require two distinct interventions: one designed to establish preattention, the other designed to establish attention. Presumably, for children with learning deficits, the preattention phase would be a necessary initial step for subsequent successful learning. Conversely, if such a functional independence between preattention and attention cannot be demonstrated, the Etzel et al. (1981) distinction is misleading; potentially it would result in educators developing and implementing two interventions when only one would be necessary. The second purpose of the present study, therefore, was to answer the empirical question of whether an intervention that reliably establishes the behaviors that Etzel et al. (1981) define as preattention also establishes the behavior they define as attention.

The initial intervention consisted of using the directional aspect of an auditory cue to induce preattending behaviors that were hypothesized to be requisite to visual discrimination learning. In addition to reporting the technique's utility in establishing task-relevant orienting behavior, we report the effect of the intervention in training children to associate a specific auditory label with a specific visual stimulus. Teaching children the latter relationship is the ultimate objective of our training, and conforms to Etzel et al.'s (1981) definition of attention.

Experiment I: Establishing Preattending Behavior

Method

Subjects

Two males and one female, ages ranging from three years, six months to four years, one month, served as subjects for this experiment. The subjects' average mental age was approximately three years, one month. Each subject attended a half-day preschool program for high risk children. Each subject was described as demonstrating expressive language delays and attentional problems by the staff of the program. The staff attributed the children's delays to impoverished environmental backgrounds and lack of stimulation during infancy.

Procedures

Condition A: Non-directional Auditory Cueing

In individual sessions, each child was seated before an automated display which consisted of two 6" by 6" translucent panels, positioned three feet apart. Slide projectors hidden behind the mechanism projected the visual stimuli to the panels.

In addition, each panel had a concealed speaker mounted directly adjacent to it. The child sat approximately 2 1/2 feet in front of the display. Each child was administered 10 warm up trials consisting of 10 presentations of the visual stimuli and associated auditory stimuli. In Condition A, the children were presented with two different geometric figures, one on each panel, and simultaneously presented with a spoken word which was emitted from the speakers located to the sides of the panels. Thus, no directional cue was provided. To ensure that pre-experimental exposure to specific stimuli did not influence performance, novel geometric figures and words that were meaningless to the children were employed. The geometric forms were and and the associated words were "confect" and "fulsome," respectively. In order to earn reinforcement, the child was required to press the panel on which was projected when the auditory cue was "confect"; he or she was required to press the panel on which was projected when the auditory cue was "fulsome." The auditory stimulus, presented with equal volume from both speakers on a given trial, was randomly determined and the geometric forms were alternated between the two panels. The geometric forms were exposed until either a response was made or for 15 seconds on each trial. When a response was made, the trial ended immediately whether the response was correct or incorrect.

Following each correct panel press, the child was reinforced with a recording of five seconds of music, verbal praise (e.g., "good" or "that's right!"), and a variety of small edibles. Following each incorrect response, the panels were immediately darkened and an intertrial interval was begun. The intertrial interval was generally 15 seconds, exceptions being when the child made a panel press during the last five seconds of the intertrial interval. On these occasions, the onset of the next trial was postponed for five seconds following the last intertrial response. This time-out from the opportunity to work for reward was designed to eliminate indiscriminate responding that otherwise might be maintained by adventitious reinforcement through the illumination of the panels. An accuracy criterion was set at 80% correct responding for a block of 20 test trials. Success within a particular phase was defined as reaching criterion on three consecutive blocks of 20 trials.

Condition B: Directional Auditory Cueing

All contingencies that obtained in Condition A also obtained in Condition B. The differentiating feature of Condition B was that the auditory cue was localized; i.e., was emitted only from the speaker that was located on the side of the "correct" panel. Thus, on some trials, the child consistently heard "confect" from the speaker to the side of . On other trials, the child consistently heard "fulsome" from the speaker to the side of .

After an individual child had reached a relatively stable rate of responding in Condition A, Condition B was introduced (see Figure 1). In order to minimize the possibility that the child would not remember any learned association between the auditory and visual stimuli, the condition changes were made intra-sessionally; i.e., after 10 warm up trials in one condition, there was a shift to the alternate condition for the 20 test trials (e.g., 10 in Condition A, 20 in Condition B). The following day's session consisted of a continuation of the condition that was in effect at the end of the preceding session. Following attainment of stability in Condition B, there was a reversal to Condition A. Finally, Condition B was reinstated.

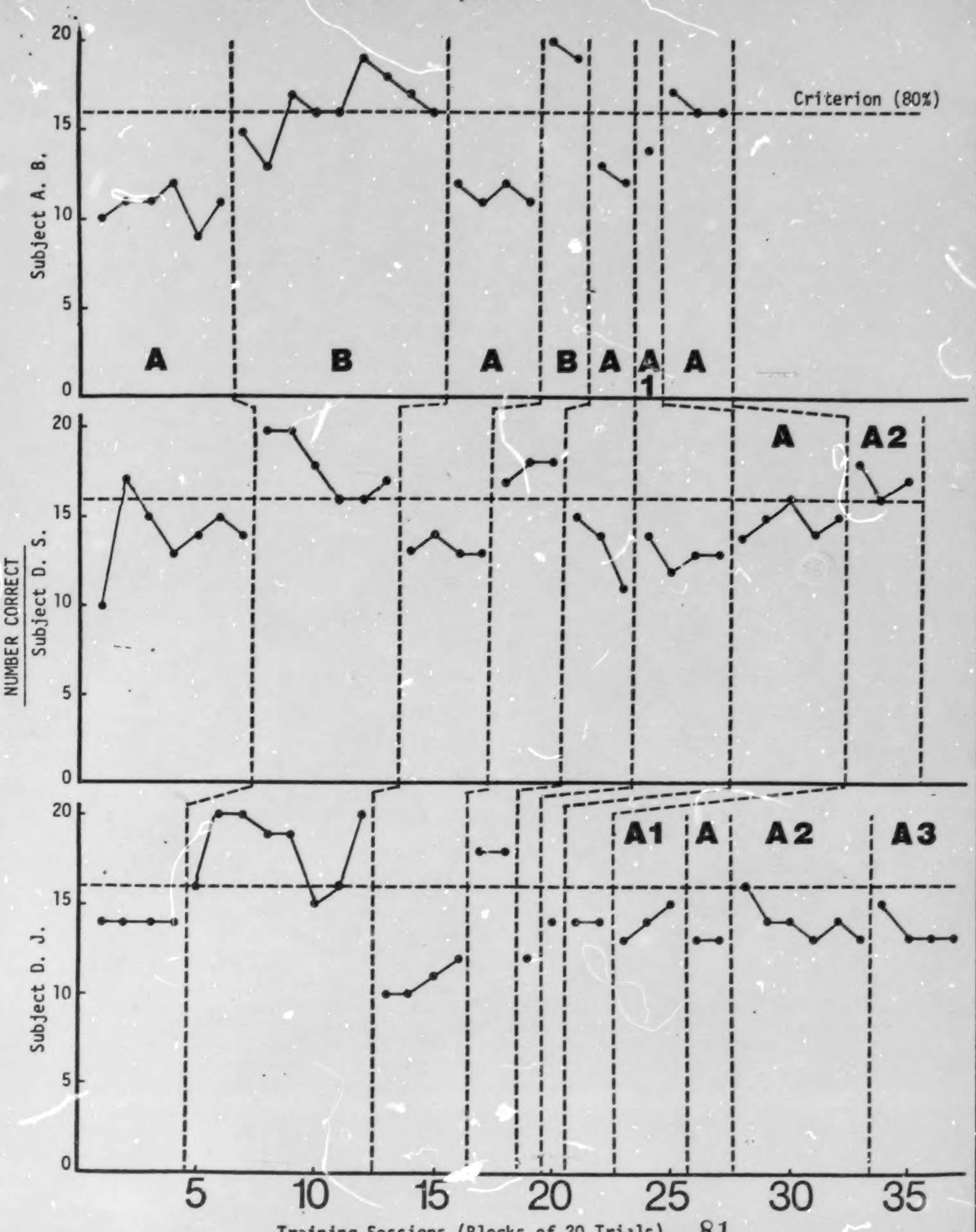
Reversal to Condition A was designed to provide information about the extent to which the directional aspect of the auditory cue remained functional, i.e., whether it continued to be necessary in order for the children to reach criterion. This manipulation thus provided information as to whether the children had attended to the geometric forms and associated them with their respective auditory cues.

Results

Figure 1 illustrates that none of the three children consistently achieved the predetermined accuracy criterion of 80% correct responding in the blocks of 20 trials in Condition A. In contrast, this criterion was reached in Condition B within three sessions by subject A. B., and within one session by subjects D. J. and D. S. After achieving the criterion, each child maintained high rates of accurate responding for the remainder of Condition B.

Figure 1 also shows that when there was a reversal to Condition A, there was also a reversal to baseline levels of accuracy. Thus, the directional auditory cue continued to be necessary for the children to make the "correct" choices; exposure to Condition B did not enable the children subsequently to respond accurately without the directional cue. This is illustrated by the low percentage of accurate responding in the second A Condition. Confirming the functionality of the directional auditory cue, the accuracy criterion was again achieved by each of the children with reinstatement

Figure 1


Criterion (80%)
Subject A. B.
A
B
A
B
A
A 1
A
NUMBER CORRECT
Subject D. S.
A
A2
Subject D. J.
A1
A
A2
A3
0
5
10
15
20
5
10
15
20
25
30
35
Training Sessions (Blocks of 20 Trials)

of the B Condition, indicating at minimum that the children could utilize an auditory cue in their orienting response.

Experiment II: Establishing Educationally Relevant Attending Behavior

At this point, an obvious question remains unanswered: How to induce the children to attend to the auditory and visual stimuli in a manner that would enable them to associate the two, since up to this point, no "learned association" had been demonstrated. This is an important question practically, because, as noted previously, coordinated bimodal receptor utilization is fundamental to successful performance on a range of educational tasks, including object naming and reading comprehension (Birch, 1962; Sidman, 1971; Sidman & Cresson, 1973).

Stimulus Fading. The first intervention, Condition A1, employed to induce the children to attend to the auditory and visual stimuli in a coordinated manner, consisted of fading the directional aspect of the auditory cue. A modification of the stimulus materials was necessary in order to implement this intervention. With respect to the two speakers used in Experiment 1, five normal adults were instructed to give their judgements as to what "sounded like" a 75% of the volume from one speaker, and 25% of the volume from the other speaker. Individually, the judges were seated in the same small chair as the children; the chair was placed directly in front of the two panels and their associated speakers. Different volumes were presented, using both ascending and descending series, until each judge was consistent in her or his designations. Only very minor differences in designations were obtained among the five judges, and a median designation of 75% and 25%, taking into consideration the designations of all the judges, was regarded as the veridical 75% and 25%, respectively, to be used with the children. This volume ratio was then randomly alternated, depending on the "correct" side.

As noted, in the B Condition the auditory cue was emitted only from the speaker directly to the side of the geometric form that, on that particular trial, was designated as the correct choice. After stable, high levels of accurate responding (i.e., at or above criterion) were established in B Condition warm up trials (i.e., 100% directional cueing) an intra-sessional shift was made to the new condition, A1. In Condition A1, 75% of the volume of the auditory cue was emitted from the correct side speaker and 25% of the volume was emitted from the incorrect side speaker. When an individual child displayed stable levels of responding with the 75-25 directional cueing, a reversal was made to the condition wherein the auditory cue was emitted at equal volume from the two speakers, i.e., Condition A, non-directional cueing. Reinstatements of Condition A1 followed by reversals to Condition A were carried out until stable responding in Condition A. Condition A thus was used as the test condition to determine whether an individual child could make correct choices without benefit of directional cueing, as it had been so used in Experiment 1.

Results

Following exposure to Condition A1, one of the children, subject A. B., exceeded the accuracy criterion to 16 correct choices out of 20 trials in Condition A. His accurate responding proved to be relatively stable. He attained criterion during three blocks of 20 trials, at which point training was concluded for him. It should be noted that this child had not previously reached the criterion of 16 out of 20 in the A condition in a full 200 trials.

While the introduction of stimulus fading in Condition A1 thus was effective in training subject A. B. to use the auditory cue in selecting visual stimuli, it was less effective with subjects D. J. and D. S. It may be noted that subject D. S. did reach the accuracy criterion during the third block of 20 trials in Condition A following the introduction of fading Condition A1, whereas he had not done so in the preceding 240 trials. However, subject D. S. did not stabilize at this level of accurate responding as had subject A. B. In view of this consideration, subjects D. S. and D. J. were provided with another intervention, Condition A2.

Stimulus Familiarity Fading. In hopes of inducing D. S. and D. J.'s attention to the requirements of the task (i.e., associating the auditory and visual stimuli and utilizing the former in selecting the latter), an attempt was made to increase the salience of the task demands. In a new condition, A2, the novel geometric forms and unfamiliar auditory cues were replaced by drawings of familiar stimuli: a box and a ball and their associated common names. The children were reinforced for selecting the box on trials when the auditory cue was "box"; they were reinforced for selecting the ball on trials where the auditory cue was "ball." In each training session, the first 10 trials consisted of presentation of these stimuli. Then there was a change back to the original two novel geometric forms and to their associated cues, "confect" and "fulsome", for the 20 test trials of the session. This intervention might be described as a stimulus or familiarity fade because the children were provided with a task consisting of familiar stimuli. We hypothesized that this familiarity with the stimuli would increase the saliency of the activity that the task demanded--i.e., attending to and perceiving a relationship between an auditory cue and a visual form. In Condition A2, the sequence of 10 trials with the familiar stimuli followed by 20 trials with the unfamiliar stimuli was maintained until the children stabilized with respect to accurate responding during the trials when the unfamiliar stimuli were presented.

Results

Subject D. S. exceeded the accuracy criterion in responding to the unfamiliar stimuli during introduction of Condition A2. His performance proved to be relatively stable: He reached this criterion on three consecutive blocks of 20 trials, at which point training was concluded for him. It may be noted that, prior to introduction of Condition A2, Subject D. S. had reached this criterion only twice when responding to the unfamiliar stimuli in 19 blocks of 20 trials; i.e., in a full 380 trials.

The remaining subject D. J., reached the criterion of 80% accuracy during one block of 20 trials upon the introduction of Condition A2. However, she did not maintain this level of accuracy, and subsequently failed to reach this criterion on several other blocks of 20 trials. Hence the following intervention was devised for this remaining subject.

Enhancing the Saliency of the Response-Reinforcer Relationship

It was noted that in the preceding phases of the present experiment the children pressed a panel in one location and reinforcement was delivered in a slightly different location, the food magazine. Although this is a commonly used experimental arrangement, the relationship between the response and the delivery of the reinforcer is relatively abstract and arbitrary. Shepp (1960) found that making salient the functional relevance of a response in earning reinforcement by putting candy in a manipulable container enhanced pattern learning with retarded children. Hence, in condition A3, subject D. J. was presented with a device with two small doors, each with a handle that could be grasped to raise the door.

Diagrams of the two novel geometric forms used as stimuli in the preceding phases were attached respectively to the two doors, thus again presenting the child with the choice that she had been presented within the preceding phases. If she raised the door with the correct geometric form, she could then reach inside the device to take a small edible. Conversely, if she made an incorrect choice, she found the device was empty.

In the current phase, A3, the function of the response in obtaining reinforcement was, by comparison, to the preceding phases more salient. Aside from this change that enabled the child to open a manipulandum and explore its contents, all conditions were the same as in the preceding phases. Subject D. J. was given warm up trials with the new device and then presented with the original, more arbitrary, experimental arrangement. However, she never stabilized at the accuracy criterion.

Discussion

Etzel et al. (1981) defined preattending behavior as a variety of behaviors including posture and orienting and observing responses that have a high probability of bringing the child closer to or in contact with stimuli that will subsequently control adaptive attending behavior. In addition to being effective in inducing the preattending behaviors that Etzel et al. (1981) specify, the directional auditory cue also induced the behaviors of reaching and panel pressing. These latter responses are requisites of practically all automated training tasks. Since a good case can be made for the utility of automation in training various abnormal populations (Deckner, Wilcoxon, Maisto, & Blanton, 1980), a procedure that consistently establishes and maintains high levels of these preattending behaviors may be a useful addition to the armamentarium of professional educators.

The present results also attest to the practical significance of Etzel et al.'s (1981) distinction between preattending and attending. While effective with respect to establishing the various preparatory behaviors (i.e., preattention), it was evident that the directional-cue intervention did not establish the association of a specific auditory cue with a specific visual stimulus (i.e., attention). In particular, the accuracy of each child's responding abruptly declined to a level below criterion following reversal to the A condition. The directional-cue intervention may therefore be regarded as a technique that differentiates empirically between preattention and attention in an educationally important context. Prior to the acquisition of these results, there was basis for asserting that the practical importance of Etzel et al.'s (1981) distinction had not been demonstrated.

The results of the present series of experiments also are taken to support the implication of Etzel et al. (1981) that a biphasic intervention is necessary for some children: the first designed to establish preattention; the second designed to establish attention. It was noted that initially none of the children attained criterion in Condition A, a condition that required both preattention and attention. Conversely, all three children rapidly attained criterion when they were required only to use the directional aspect of the auditory cue to orient themselves toward and press a particular panel. This latter condition, Condition B, can be construed as only requiring the preparatory behaviors Etzel et al. (1981) define as preattention.

While the intervention designed to establish preattention was uniformly effective, establishing focused attention was much more difficult. Interventions had to be tailored for the individual children, and even then one of the three failed to attain a predetermined criterion of stable, accurate responding.

With regard to establishing attention, the following observations were made: One child reached our predetermined criterion when provided with training that consisted of fading the auditory directional cue. A second subject did not reach criterion following directional-cue fading but did so with training that consisted of a stimulus familiarity fade. In addition to these two interventions, the third child was trained with an intervention designed to increase the salience of the response-reinforcer relationship. However, this last child was never able to attain the criterion taken to indicate focused attention.

The results of the stimulus familiarity fading procedure suggest the importance of the subject attending to the task demands. In the present experiment, Subject D.S. had had 330 trials and did not attain success with the unfamiliar stimuli until the salience of the task demands were increased by providing him with familiar auditory and visual stimuli. This suggests that what was transferred was not a specific stimulus-response association, but an increase in the salience of the relevant stimulus information; i.e., relationship between an auditory cue and a visual form. Put another way, the task activity itself and not merely the physical aspects of the auditory and visual stimuli, afforded important information that was perceived and utilized. However, the failure of the final subject to stabilize at criterion, even after attempts to make salient the relationship between the response and reinforcer, indicates the need to investigate further the efficacy of these techniques across a variety of subjects.

In summary, the present study demonstrates a technique, directional auditory cueing, that has subject generality in evoking preattending behaviors that are fundamental to appropriate responding in visual-discrimination learning. In addition, two procedures, auditory directional cue fading and stimulus familiarity fading, appeared to have utility in establishing adaptive, focused attention with some low functioning children. These results support Etzel et al.'s (1981) contention that there is a distinction between pre-attention and attention that is important from the standpoint of trainiing. The present results also indicate that additional research is needed to develop more generally effective techniques to establish focused attention in low functioning children.

Oddity Performance and the Perception of Relational Information

The oddity paradigm requires the subject to choose one stimulus from a set of stimuli; typically, the stimuli are presented in a visual array. The odd stimulus varies in one important dimension from the other, nonodd stimuli, which are identical on that dimension (such as form, color, or size). An important aspect of the oddity paradigm is that it demands the utilization of relational information afforded by the visual array in order to make a correct choice. That is, an individual stimulus does not possess discrete informational value apart from its relationality with other stimuli in the array.

Certain investigators of oddity performance have demonstrated a facilitative effect of stimulus variation, in which the odd (S+) stimulus and nonodd (S-) stimuli change from trial to trial. Others, however, have found such variation to be detrimental to performance (House, 1964; Saravo, Bagby, & Haskins, 1970; Scott & House, 1978). Subtle and significant variation in the task demands of oddity studies, especially measures of success and transfer, contribute to the noncomparability of much of the literature. Also, oddity tasks typically involve the performance of children five years of age or older; these particular children are able to solve oddity tasks readily and are less sensitive to task dimensions that contribute to variability in younger children, such as repetition and variation of discrete cue features (see House, Brown, & Scott, 1974, for a review).

The reversal shift has been shown to be one of the more stringent tests for oddity acquisition. In this procedure, a child is reinforced a number of times for selecting a particular stimulus with a constant physical configuration. This stimulus is typically embedded in an array of homogeneous stimuli that differ from the target stimulus on some dimension. The reversal shift consists in changing the array stimulus elements such that the previously reinforced "odd" stimulus configuration now becomes the multiple non-odd array stimulus; the previously non-odd stimulus becomes the correct choice as the "odd" element. Accurate performance of this reversal shift would indicate attention not only to the physical dimensions of the stimuli (such as those of the previously reinforced odd stimulus), but also to the relations among all of the stimuli in the array (House, 1964). Children in younger age groups are usually unable to make use of relational responding in order to succeed at reversal shifts with arrays of three discrete stimuli.

It has been suggested that the ability to solve oddity problems involves attentional (Zeaman & House, 1963; Brown & Scott, 1974; Scott & House, 1978), perceptual (Zentall, Hogan, Edwards, & Hearst, 1980), and conceptual (Gollin & Schadler, 1972) factors. Lane and Rabinowitz (1977) claim that both perceptual and conceptual factors are operative in standard size transposition tasks; these tasks also demand the use of relational information and are thus analagous to the oddity task.

The traditional theories of oddity performance are basically stage models. House et al. (1974) proposed a sequence of (a) attend to the vehicle dimension, (b) attend to relational cues, and (c) execute the oddity choice. Bowers' (1976) model has as its initial step the selection of an oddity rule, and then proceeds to the vehicle dimension and subsequent oddity choice stages. These stage models are essentially mediational; i.e., a dimension or rule selection presumably occurs through some conceptual mediation between stimulus input and oddity choice. Oddity performance is thus assumed to be an ability requiring conceptual mediation, and the relationships among stimuli are defined in a conceptual manner.

Oddity Performance and the Perception of Relational Information

One effective method of facilitating oddity performance is to change the visual array, so that there is a greater number of identical, non-odd choices (Gollin, Saravo, & Salten, 1967; Gollin & Schadler, 1972; Zentall, Hogan, Edwards, & Hearst, 1980). However, in those studies, subjects were not always able to transfer positively from the arrays with many stimuli to arrays with fewer non-odd stimuli. The present authors assume, nevertheless, that as the number of non-odd elements decreases, the perceptual salience of the odd stimulus simultaneously decreases. When an odd stimulus is embedded in a two-dimensional array of many non-odd homogeneous distractaors, its uniqueness is more readily perceived. This positive relationship between the number of stimuli in the array and perceptual salience forms the rationale for the present study.

The present investigation employed an intervention during training consisting of increasing the number of elements in an oddity task. We hypothesized that by increasing the number of identical, non-odd stimuli in the visual oddity array from two to eight, subjects could be trained to demonstrate oddity learning based on the increased salience in a subsequent stringent reversal shift assessment. We also expected that success with reversal shifts in the large array would transfer positively to reversal shift assessments of oddity performance in small arrays. Finally, by using subjects at a developmental stage commonly regarded as one at which relational oddity responding is atypical (below a CA of 4 years), we hoped to demonstrate the power of a perceptual intervention to induce successful oddity performance in young children for whom conceptual factors would presumably be minimized or perhaps non-operative.

Method

Subjects

Two boys and two girls were selected from a class for developmentally delayed children at the John F. Kennedy Institute of George Peabody College of Vanderbilt University. Chronological age (CA) ranged from three years two months to three years eleven months, while mental age (MA) ranged from two years seven months to three years four months. Subjects were selected on the basis of their ability to attend to the experimental task and to make discrete responses. The assessment procedure is described below; no subjects had prior exposure to oddity learning tasks.

Stimuli

The stimuli were Arabic numerals depicted on 12" x 12" manila cards. The cards were subdivided into 3" x 3" squares (see Figure 1).

Three stimulus array. The first set of stimulus arrays was used during the baseline and return-to-baseline phases. This set of arrays consisted of subsets, each containing six training cards and three reversal shift assessment cards. On the training cards, the two nonodd identical S^-s and odd S^+s were positioned so that the S^+ appeared an equal number of times in each of the three rows and three columns on the six training cards. Subject to the constraint of varied placement of the S^+s, S^-s were randomly positioned in the remaining eight vacant locations on the card. This strategy (varying the position of the S^+ and S^-s in the array) was employed to discourage positional response sets.

The three reversal shift assessment cards were similarly constructed. The odd S^+ appeared in a different row and column on each card (see Figure 1). However, the Arabic numeral that was the S^+ on the six training cards was now the S^- on the reversal shift cards, and the former S^- numeral was now the odd S^+ on the training cards. If the subject could shift from choosing the S^+ on the training card to choosing the S^+ on the reversal shift cards (the previous S^-), this would indicate a successful reversal shift.

Nine stimulus array. The cards used during the intervention (Phase B) were constructed along similar lines to the three stimulus array as far as the positioning of the S^+ is concerned. Now, however, all vacant positions not occupied by the S^+ in training and RS assessment cards were filled; there were eight identical non-odd stimuli (S^-s) on each card (see Figure 2).

The sets of arrays used during Phase A (Baseline), Phase B (Intervention) and Phase A (Return-to-baseline) consisted of several subsets of training and reversal shift assessment cards. The Arabic numeral pairs chosen for the several subsets were randomly chosen from the numerals 1 through 9.

Design

An intra-subject reversal design was employed in conjunction with a multiple baseline across subjects design (Hersen and Barlow, 1976). The single subject methodology was especially appropriate for the present study because it would provide a clear test of the effect of the intervention. In the multiple baseline design, the intervention (Phase B) is introduced differentially with respect to the time the subjects have been exposed to a baseline measure (Phase A). This design thus ensures that subjects are exposed to varying numbers of training and reversal shift stimuli (see Table 2). Changes in performance are then clearly attributable to the intervention rather than such factors as length of time-in-task, or number of reversal shift stimuli received during the baseline assessment of oddity performance.

Successful performance on reversal shift assessments was considered to be indicative of oddity-based responding. Criterion for presentation of reversal shift assessments was three consecutive correct responses on the training set stimuli. The probability of three consecutive correct choices occuring by chance with the three-stimulus array (Phase A and return-to-Phase A) was $(1/3)^3$ or 1/27. The probability of three consecutive correct choices with the nine-stimulus array in the intervention, Phase B, was $(1/9)^3$ or 1/729.

Baseline. Phase A consisted of establishing baseline responding on training stimuli and reversal shift assessments with the threestimulus arrays (one odd, two identical nonodd stimuli) arrays. When an S reached criterion of three consecutive correct S^+ choices on a set of training stimuli (six training cards presented in random sequence), reversal shift assessment cards were presented. Upon making an error on a reversal shift card, a new set of training stimuli was presented, and the procedure was repeated. Our criterion for oddity-based responding in Phase A was correct responding on five reversal shift assessments (three cards per each assessment).

Intervention. Subjects began training on the intervention, Phase B, at different points in their exposure to Phase A, as required by the multiple baseline design. Our criterion for success on Phase B was correct responding on seven reversal shift assessments, or 3 x 14 = 42 actual RS trials. When the S reached this criterion, we regarded the subject as having attained the performance criterion of oddity-based responding.

Table 1

	Phase A (Baseline)	Phase B (Intervention)	Phase A (Transfer)
Stimuli	3-stimulus array (one odd, two identical nonodd stimuli)	9-stimulus array (one odd, eight identical nonodd stimuli)	3-stimulus array (one odd, two identical nonodd stimuli)
Criterion for oddity-based responding	5 RS sets correct 3 x 15 = 45 RS trials	7 RS sets correct 3 x 21 = 63 RS trials	14 RS sets correct 3 x 42 = 126 RS trials

Table 2

Percent Correct of RS Assessments Presented to Each Subject

Subject	Phase A	Phase B	Phase A
A	25.0 (8)	43.4 (53)	87.8 (49)
B	0 (16)	75.0 (24)	89.6 (48)
C	0 (14)	32.8 (64)	95.4 (44)
D	0 (11)	68.6 (35)	87.0 (46)

Note. Number in parentheses represents actual number of RS trials, which varied across subjects depending on each subject's performance with training stimuli (see text). To advance to the return to Phase A, a minimum of 21 RS trials was required; to terminate after the return to Phase A, a minimum of 42 RS trials was required.

Transfer. After reaching criterion during the intervention (Phase B), S's were again presented with three-stimulus (one odd, two identical non-odd stimuli) arrays to test whether relational responding would be applied in a task in which subjects previously had failed to show such responding. Subjects had to reach criterion on 14 subsets of training stimuli and reversal shifts to complete the return-to-baseline phase. Stimuli (S+ and S-) for these subsets, as in previous phases, consisted of randomly selected pairs of Arabic numerals. Due to the complexity of the stimuli used, it was assumed that if subjects succeeded during the final phase, a generalization test with simpler stimuli such as geometric forms or colors would not yield further information.

Procedure

Subject assessment. Prior to the first experimental session (Phase A), subjects were presented, in random sequence, nine cards. Each 12" x 12" card had a drawing of a familiar object (ball, bicycle) in one of the nine spaces. Subjects were reinforced with small edibles for touching the drawing. This was done to be certain that subjects could perform the appropriate testing response (touching the stimulus), and maintain attention to the task.

Each child was brought to the experimental room by the experimenters. The subject sat in a chair facing a table on which the stimulus cards were presented by a female experimenter, who sat to the subject's right. The cards were held perpendicular to the table surface directly in front of the child, so the child could easily view the entire array and reach the card to make touching responses. The male experimenter sat directly behind the subject to collect data and administer reinforcers.

Data collection. Upon presentation of the stimulus cards and reversal shift assessments, the child was asked: "Which is it?," or "Tell us which it is." Verbal feedback was provided for each response ("Yes, that's it"; "No, that's not it"). Edible reinforcers were provided on an intermittent basis (variable ratio) during training trials, but never during reversal shift assessment trials. Reliability checks were made during eight of the twenty-five experimental sessions. Interrater reliability for correctness of response was r = 1.00; reliability for position of response in the array was r = .98. Errors on the latter measure were due to restriction of the reliability checker's view of the array by subjects' occasional erratic movements.

Sessions were limited to one per day; occasionally sessions were separated by more than one day. Each session consisted of approximately 40 trials; the session was never ended during an reversal shift assessment.

Table 1 summarizes the sequential administration of the three and nine-stimulus arrays during each phase of the experiment. Failure to attain criterion for oddity-based performance in Phase A was necessary for inclusion of the subject in the study. Otherwise, the effectiveness of the intervention could not be tested. After subjects proceeded to Phase B in accordance with the multiple baseline design, attainment of the criterion of 14 correct sets of RS assessments (42 RS trials, three cards per set) was necessary for the subject to proceed to the transfer task (return to Phase A).

Results

Figure 3 shows that the intervention procedure (Phase B) was effective in inducing RS oddity responding in all of the experimental subjects. The most interesting result occurred subsequent to the the return to baseline, that is, to the three-stimulus array of Phase A after Phase B. Here two subjects, A and D, transferred within 20 trials in the return to Phase A to stable correct oddity-based responding on RS assessments. The other two subjects, B and C, began responding correctly almost immediately.

Transfer on the return to Phase A, especially when subjects' initial performance in Phase A is taken into consideration, was rapid and reached surprising stability. Within approximately 70 stimulus trials in the return to Phase A, all subjects reached the termination criterion of 14 correct sets of RS assessments consisting of 42 actual trials.

After the introduction of the intervention, Phase B, two subjects began responding correctly to reversal shift assessments within 20 trials. The other two subjects were in the Kennedy Center program for remediation of attentional as well as other difficulties. They took longer to respond to the intervention, as their level of attention varied. Once reversal shift responding was established, their performance reached the accuracy and stability of the other subjects.

Table 2 shows the actual percentage correct of reversal shift assessment received by each subject during each phase. Since presentation of reversal shift assessments was contingent upon subjects reaching criterion tracking the odd stimulus on the stimulus sets, the actual number of reversal shift assessment trials presented in each phase is included. This provides an indication of each subject's level of functioning with the task in the initial Phase A. Since chance responding on reversal shift assessments would lead to a 33 $^1/_3$% correct response level during reversal shift trials, the low level (i.e., below 33.3%) achieved by each subject indicates a strong stimulus-bound response strategy (analysis of errors also indicated reversal shift responses were much less affected by the position of the previous correct choice than training stimulus trials). Also, when poor reversal shift responding during the initial Phase A is constrasted with acquisition and maintenance of relational (oddity) responding during Phases B and the return to Phase A, we can observe that the intervention strategy for inducing oddity performance was quite effective. In short, all subjects were able to break strong stimulus bound response strategies in a task designed to provide a stringent test through reversal shifts of true oddity performance.

Discussion

Results from previous studies had shown an inability in normal children under the age of approximately five to succeed consistently at a variety of oddity and transfer tests (reviewed by House, Brown, & Scott, 1974). However, even with young developmentally delayed children (3 to 4 years CA, 2 years 7 months to 3 years 4 months MA), a difficult oddity discrimination was facilitated in the present study. This was accomplished through an intervention that was designed to enhance the perceptual salience of the odd stimulus.

The present study has thus demonstrated that it is possible, even with developmentally delayed children between 3 and 4 years of age, to induce a sophisticated relational discrimination subsequent to manipulation of a perceptual dimension in a visual array. More importantly, the child is able to transfer to an oddity array of minimal elements (one odd and two identical, nonodd stimuli) successfully. Prior to the intervention the children in the present study were unsuccessful at the traditional reversal shift tests for oddity-based performance.

Gibson (1966) has discussed visual perception as the detection of information in a visual array. The visual array can include information of higher order invariant relationships among elements such as those required in oddity tests with reversal shifts.

Success on a reversal shift in which the previously reinforced odd stimulus becomes the nonodd stimulus of the homogeneous field, and vice versa, demands the utilization of relational information. This suggests the transfer of both oddity learning and a less stimulus-bound perceptual set. Sugimura (1981) has found evidence for the postulation of a relational component in all oddity learning. This is consistent with the theme of the present study, where the odd stimulus was made more perceptually salient by increasing the number of non-odd elements; i.e., the relational characteristics of the odd and non-odd elements were directly manipulated.

One important implication of the present study is that failures in the past to induce successful oddity discriminations in children younger than 5 years of age may be due to complex or changing experimental task demands. Specifically, the visual arrays provided to the children in these studies may have been structured inadvertently so as to provide minimal or impoverished relational information. For example, Gollin and Schadler's (1972) use of a reversal shift test for oddity acquisition, with the stimuli positioned in a row, might have induced a visual scan of individual elements, rather than a "perceptual" field such as one experiences with stimuli presented in matrix form. Since the three-element horizontal row is used frequently in oddity studies, this may be a factor confounding results and reducing comparability to other studies, as well as affecting performance on transfer tasks. As another example, Ellis and Sloan (1959) demonstrated poor oddity performance in younger children; however, in their study, three dimensional forms were used which elicit more complex scanning behavior, and this might have interferred with the detection of the critical wholistic oddity percept. Supporting this view is the work of Zentall et al. (1980), who found that pigeons made oddity discriminations most efficiently when the position of the odd stimulus was maximally varied in a 5 x 5 (25 position) array. That is, scanning of individual features of the three dimensional objects may not produce the perceptually salient features of a stimulus embedded in an array of many non-odd distractors. The assumption here is that the subject has the capacity to view and perceive the two dimensional array as an essentially wholistic image.

Another difference between Gollin and Schadler's (1972) study and the present one is that their reversal shift test occurred as a final oddity transfer test; it was the subject's first encounter with a true reversal shift. In the present design, the child was exposed to reversal shift assessments repeatedly throughout the study; as the subject reached criterion on training stimulus discriminations a reversal shift was always presented immediately. It appears that the repeated introduction of reversal shift assessments, in conjunction with the manipulation of perceptual dimensions of the array, may be helpful in inducing subsequent successful transfer to arrays of minimal elements. Subjects' failure at reversal shift assessments during Phase A, however, would indicate that exposure to reversal shifts throughout the task in itself is insufficient to induce oddity-based performance on reversal shifts. A supplementary perceptual manipulation is perhaps necessary for true oddity responding in younger children.

Since the present study demonstrated successful oddity performance on a stringent reversal shift assessment with very young children, previous assumptions concerning the development of this relational skill may be questioned. We account for the frequently observed positive relationship between successful oddity performance and developmental age in the following way. We suggest that oddity performance reflects an ability to directly perceive relational information in a visual array. It may be that the performance of older children (e.g., of ages 5 or 6), who usually succeed at varied oddity tasks, can be explained by an increased sensitivity to relational information. Younger children, it appears, may require a higher degree of perceptual salience in an array to perform difficult oddity tasks, yet they can perform, with great stability as indicated here, tasks that are alleged to be conceptually or symbolically mediated. This is in contrast to the notion of Inhelder and Piaget (1970) that language and symbolic representation are necessary for classification and seriation (oddity being a singular class concept). Odom and colleagues (Odom and Guzman, 1970; Odom and Mambauer, 1971) have emphasized the role of perceptual salience in typical problem solving and analysis-synthesis developmental tasks. They argue that as children grow older, they develop a greater perceptual sensitivity to relations in the environment as a result of experience. Their results demonstrate that experimental tasks can be designed with dimensions that are sufficiently salient for very young age levels. These children can achieve successful performance on tasks that were previously considered to require the "higher" conceptual processes of older children. Relating this perspective to the present experiment, it can even be argued that the "conceptual" demands are similar in the three stimulus array and nine stimulus array. Thus, the success of the nine-stimulus array in inducing oddity performance on the reversal shift, and the subsequent transfer of this skill to the three-stimulus arrays, suggests that perceptual factors have primary importance in oddity performance.

As previously noted, current theories of oddity learning (e.g., see House et al., 1974; Bowers, 1976) are essentially stage models, which demand conceptually driven rule utilization at some point in a response chain. It may, however, be unnecessary to posit such a sequence of stages with concomitant mediational processes. The present data suggest that the direct perception of relational information present in a visual array is a more parsimonious model of oddity learning than the traditional mediational models.

The Effect of Contingent vs. Non-Contingent Presentation of Rhythmic Asynchronous Stimulation on the Stereotyped Behavior of Children with Autism

Introduction

Stereotyped behavior can be defined as a class of behaviors, all of which are oscillatory body movements involving repetitions of the same motion, e. g., a hand flap, at an apparently uniform frequency of oscillation and in a remarkably stable form. These behaviors can be observed in normal, brain damaged, mentally retarded, schizophrenic, blind, and autistic populations.

Stereotyped behavior is generally considered a common behavioral characteristic of autism (Kanner, 1943; Rimland, 1964; Wing, 1966; Lovaas, 1971). Though stereotyped behaviors are not usually considered one of the necessary and sufficient symptoms for a diagnosis of autism, it is generally agreed that these behaviors can be observed in a majority of autistic children (Ornitz and Ritvo, 1976). As Lovaas (1971) noted, of those autistic children with histories of stgereotypy, "self-stimulation or autoerotic behaviors" are "by far the most frequently occurring (spontaneous) behavior."

The prominent communications dysfunction of autism is sometimes manifested through verbal stereotypy. It has been argued that the echolalic repetition of words apart from their meanig might be maintained by the same stimulus controls as other stereotyped behavior (in this case, repetitive auditory and articulatory feedback).

Stereotyped behavior closely reflects an unusual responsiveness to sensory stimuli. The question of whether or not stereotyped behavior occurs as one of several unusual responses to internal and/or external stimuli is the major focus for the present investigation. It appears that the internal stimulus feedback from these behaviors is at least partially relevant to its occurrence, since experimental blocking of even part of this feedback can decrease the occurrence of the behavior itself (Ornitz, Brown, Sorosky, Ritvo, and Dietrich, 1970). There is evidence that stereotyped behavior may also occur as an unusual response to non-contingent or contingent external stimulation.

More particularly, stereotyped behavior apparently reflects a disturbance in responses to people, events, and objects, in that the onset of stereotypy might occur as the initial (or only) response to the introduction of each. Novelty in attendant personnel, in situations or the ordering of events, and in objects presented, will often be met with onset or intensification of stereotypy in autistic individuals, whereas social or environmental novelty more often cues decreases in stereotypy in normal, brain damaged, and mentally retarded individuals (Hutt and Hutt, 1968). This unusual response to novelty, as well as the marked topographic consistency of these behaviors across time, reflects an insistence on sameness by the person with autism; that is, a resistance to change in routine or the physical environment.

Some investigators have maintained that "clinical experience suggests that these (autistic stereotypic) behaviors may occur independently of environmental influence (Sorosky, Ornitz, Brown, and Ritvo, 1968)." Baumeister (1978) also postulated that over time, pathological stereotypy might lose whatever external stimulus controls were initially operable.

However, numerous studies have indicated that, at least within the autistic population, external factors apparently do affect the contingency structure of stereotypy. Frequency of occurrence of stereotyped behaviors has been observed to vary with changes in the novelty, complexity, intensity, and rhythmicity of environmental stimuli and with degree of social intrusion (Hutt and Hutt, 1968; Ornitz et al., 1970; Black, Freeman, and Montgomery, 1975; Colman, Frankel, Ritvo, and Freeman, 1976; Frankel, FDreeman, Ritvo, and Pardo, 1978). Behavioral interventions designed to eliminate or suppress these activities by manipulation of external contingencies have had limited success, being hampered primarily by lack of generalization of their suppression across time and when not in the presence of the trainer.

A review of both observational and intervention studies with autistic persons who engage in stereotyped behavior has indicated that the parameters of autistic stereotypy hav not yet adequately been explored and documented. The inadequacy of existing studies, when considered as a whole, is due primarily to a failure to consistently report the frequency and patterns of stereotypy across all conditions explored.

Purpose and Design of the Present Investigation

The purpose of the present investigation was to systematically observe the occurrence of stereotyped behaviors in individuals with autism in a setting which allowed the controlled variation of environmental conditions along four dimensions:

A. Stimulus Availability
B. Contingency
C. Stimulus Type
D. Object Availability

Individual stereotyped behaviors within each subject's repertoire were identified and behaviorally described prior to the investigation. The occurrence of each behavior within a three-second observational interval was then recorded using a time-sampling technique. Variation in the occurrence of stereotyped behaviors could thus be measured across each combination of experimental stimulus conditions.

Controlled Variation in Environmental Contingencies: The Independent Variables

Factor A: Stimulus Availability. Ornitz (1971) observed that there are two kinds of autistic stereotypy: that occurring spontaneously, and, as a subset of the first, that which apparently occurs in accompaniment to environmental stimulation. According to Ornitz, "Austistic stereotyped behaviors may induce sensory input as they produce motor output." For example, hand-flapping provides visual input, whirling, rocking, and head rolling all provide vestibular stimulation, and scratching surfaces provides auditory input. Each of these behaviors may be assumed to provide proprioceptive-kinesthetic input as well. That is, these behaviors are self-stimulatory, though this may not be the only, or even the primary, purpose of the behavior.

This "noncontingent," apparently spontaneous form of stereotypy can be schematized as follows:

Form I-A.

$$\begin{tikzcd} & MO_1 \arrow[dd, bend left] \\ SB_1 \arrow[ur] \arrow[dr] & \\ & SI_1 \end{tikzcd}$$

where SB is autistic stereotyped behavior at the level of muscular variation, MO is the motor output, the observable form of the behavior, and SI is the stimulus input, the sensory feedback from the behavior. The form of the sensory feedback. i.e., whether it is visual, auditory, vestibular, or proprioceptive-kinesthetic, and its quality, i.e., whether it is rhythmic, is inferred from the motor output. At this level the stereotyped behavior is considered to be spontaneous, since there is no observable change in the environment preceding its occurrence. In Form I, the stereotyped behavior itself is the hypothesized independent variable, and motor output and stimulus input are the dependent variables.

Ornitz (1971) also observed that, "less frequently, abnormal motor output is induced by sensory input." That is, the internal stimulus input (feedback) from Form I may help to maintain "spontaneous" stereotypy. Ornitz's observation can be schematized as a feedback loop hypothesis of internal stimulus control, schematized as Form I-B, a variant on the first:

Form I-B.

$$\begin{tikzcd}
& MO_1 \arrow[d, bend left] \\
SB_1 \arrow[ur] \arrow[r] & SI_1 \arrow[l, bend left]
\end{tikzcd}$$

In this case, SI would becme the independent variable, and further stereotypy would be induced by the internal sensory feedback of that preceding it.

Also, another form of stereotypy, which is induced by environmental (external) sensory input may occur. One example of such "elicited" stereotypy is hand-flapping which occurs while facing a spinning object or a flushing toilet. This second form can be schematized as follows:

Form II.

$$\begin{tikzcd}
EE_2 \arrow[dr] & & & \\
& SI_2' \arrow[r] & SB_2 \arrow[r] \arrow[dr] & MO_2 \arrow[d, bend left] \\
& & & SI_2
\end{tikzcd}$$

where SI' is the external sensory input (e.g., rhythmic asynchronous stimulation), and EE is the environmental event providing the new sensory input (e.g., flash of a pair of strobe lights). In this case the external stimulus input would be the independent variable and the stereotyped behavior.

The particular experimental stimuli selected to represent Environmental Events in the Form II schematization were chosen for the appropriateness of the sensory input provided. Rates of stereotypy were observed to increase over changes in constant (incandescent) vs. flickering (fluorescent) illumination for five or six autistic subjects observed by Colman et al. (1976).

In the present investigation, subjects were observed for equal periods of time in a Baseline condition of minimal constant external stimulation, and in an Experimental Stimulus condition wherein some type of Rhythmic Asynchronous environmental stimulation waas introduced.

Baseline periods of minimal constant stimulation and assumed to mimic the external contingencies of Form I stereotypy. Stereotyped behavior occurring under this condition will be assumed to match that schematized as Form I (A or B). Experimental Stimulus Presentation periods of rhythmic asynchronous stimulation mimic the external contingencies of Form II stereotypy. Stereotyped behavior occurring under this stimulus condition will be assumed to generally match that schematized as Form II.

The present experimental design allowed comparison of "spontaneous" vs. "elicited" autistic stereotyped behavior through the juxtaposition of Baseline and Experimental Stimulus conditions (Factor A).

Factor B: Contingency. A third form of stereotyped behavior has not yet been differentiated as such in the literature. Stereotyped acts can occur in apparent accompaniment to certain relevant environmental events which have, in turn, been set in motion by the autistic child himself. That is, autistic children will sometimes work to create an environmental event to which they, in turn, engage in sterotyped mannerisms. this form of SB would be consistent with Ornitz's (1971) second description, in that it is also assumed to be "induced by sensory input" from an external event. However, Form III stereotypy accompanies external events selectively activated according to internal contingencies (criteria) specific to the individual.

For example, autistic children have been observed to toss blocks in the air from a container, then flick their fingers before their eyes while gazing at the motion of the tumbling blocks. Persons with autism have been observed to spin plates or lids on end with precision, or toss grass, shredded paper, or leaves in the air. Once performed, each of these manipulative behaviors was immediately followed by orienting, jumpinng, excited vocalizing, and/or stereotypic gesturing toward the activated motion.

The hypothesis is offered that some aspect of the stimulus array of falling blocks is 1) particularly reinforcing to this autistic child, in that the activity is repeated, and 2) is particularly relevant, in that it fits the internal criteria for "inducing" stereotypy. The resultant stereotypy is of a form, therefore, which most arguably is reinforcing, perhaps even pleasurable, to the child.

Form III stereotypy can be schematized as follows:

Form III.

$$\begin{tikzcd}
MB_3 \arrow[rr] \arrow[dr] & & EE'_3 \arrow[dr] & & & \\
& SI''_3 & & SI'_3 \arrow[r] & SB_3 \arrow[r] \arrow[dr] & MO_3 \arrow[d, bend left] \\
& & & & & SI_3
\end{tikzcd}$$

where MB is the manipulative behavior required to produce an Environmental Event (EE) with appropriate Stimulus Input (SI'). SI" signifies whatever sensory feedback accompanies the manipulative behavior. MB is now the independent variable upon which all the other variables are dependent. The diffeence between the internal stimulus feedback (SI") of the manipulative behavior, and the stimulus input (SI) of the stereotyped behavior, is noteworthy. This difference is, in fact, what makes SB rigidly invariant autistic stereotypy and MB something else entirely.

Note that, though these self-induced stereotyped behaviors are a subset of environmentally-induced stereotypy, which in turn is a subset of stereotypy in general, Forms I and II are each nested within the subsequent schematization. Of course, whether or not SB$_1$, SB$_2$, and SB$_3$ are equivalent in appearance, occurrence, and function are issues for empirical investigation, to which the results of the present study are directly relevant.

Though the existence of this third form of stereotypy has not yet been explicitly noted in the literature, two studies have been reported which model self-induced stereotypy. Frankel, Freeman, Ritvo, Chikami, and Carr (1976) presented photic stimulation of systematically varied frequencies (from 2 to 20 per second) contingent upon a lever-pull response. Freeman, Frankel, and Ritvo (1976) provided repetitive vestibular stimulation from a motorized rocking chair activated by a button-press response. In both instances, the contingent stimulation was chosen for the extent to which it was assumed to mimic stimulus input that would follow from stereotyped behavior.

Both these studies demonstrated that autistic subjects as well as mentally retarded subjects would engage inn the required manipulative behavior and produce repetitive photic or vestibular stimulation. Interestingly, in both studies autistic subjects showed a preference for certain frequencies of stimulation within the range presented, whereas mentally retarded subjects showed no such preference. Neither team of investigators recorded the effect of this free-choice contingency structure on accompanying stereotypy.

The present experimental design allowed comparison of stereotyped behavior occurring in accompaniment to environmental stimuli a) activated noncontingently by the experimenter (Fixed No Choice and Matched No Choice conditions modeling Form II), or b) controlled by the subject through a panel-press response (Choice condition modeling Form III).

Factor C: Stimulus Type. Variation in the occurrence of autistic stereotypy has been documented with respect to changes in certain physical dimensions, in the novelty of the Environmental Event, and in the degree of social interaction required in the situation. Within those studies altering physical dimensions, rates of stereotypy varied over changes in flickering vs. constant visual stimulation, where the flicker was both synchronous (Colman et al., 1976) and asynchronous (Frankel et al., 1978), when a spinning object was presented (Ornitz et al., 1970), with variation in complexity (Hutt and Hutt, 1968; Black et al., 1975), and in high vs. low levels of multimodal stimulation (Frankel et al., 1978).

The present experimental design allowed for comparison in preference and in accompanying rates of stereotypy between visual (Strobe), auditory (Drumbeat) and bimodal rhythmic asynchronous stimulation, crossed over all experimental conditions. The visual and auditory modalities were chosen for ease of experimental control, but also because of the difficulty experienced by persons with autism in processing both visual and auditory stimulation.

An hierarchy of preferences could be determined for each subject due to the paired presentation of all stimulus types in the Choice condition. Also, since No Response was followed by a 15-second "off" period--the constant minimal stimulation of Baseline--the reinforcing value of the Baseline condition could be determined relative to the three experimental stimuli.

In order to control for possible order of presentation or position effects, all experimental conditions were repeated, differing only in the order of presentation of each stimulus or stimulus pair, and in the right-left placement of stimuli within each pair.

Factor D: Object Availability. The primary manifestation of autistic stereotyped behavior is oscillatory body movement. the secondary manifestation of autistic stereotypy can be defined as involving object manipulation wherein the object has become incorporated into the oscillatory body movement as described above, with little or no regard for the object's usual function. Examples of this secondary manifestation of autistic stereotypy are flippinng a pencil, twirling a loop and batting a block back and forth. Repetitive self-injurious behaviors are specifically excluded from the category of autistic stereotypy in the present investigation since the presence of apparently painful feedback suggests other factors operational in maintaining these self-injurious acts.

The contingencies of stereotypic object manipulation are intriguing in that the rigid structure of the stereotypic movement must inevitably be flexible enough to accommodate differences in the physical structure between objects. Such an increase in variability is, however, contrary to the highly ritualistic structure of stereotypy, and to the insistence on sameness which characterizes the autistic syndrome itself.

In order to maximize the conditions for observing the relative occurrence of primary and secondary manifestations of autistic stereotyped behaviors, all previously-described conditions of the experimental design were repeated in the presence of various familiar manipulable objects. This collection of objects included at least one familiar object for each subject, the manipulation of which was part of his or her previously observed stereotypic repertoire.

Subjects

Selection of subjects was based on the following criteria: 1) a history of stereotyped behavior as reported by school personnel and confirmed through clasroom observation, 2) the presence of at least one identifiable stereotyped behavior, as defined above, during a pretest observation and videotaping period of four minutes, and 3) diagnosis of autism or of autistic-like handicaps, accompanied by one or more of the primary symptoms usually associated with the autistic syndrome. Six children met all three criteria and participated in the study.

Repertoires of individually identified stereotyped behaviors for each child were tabulated in a pretest observation period of 30 minutes by two observers. Interobserver reliability obtained for pretest observations ranged from 92% to 85%. Behaviors were categorized as primary stereotypy, involving rhythmic and repetitive oscillatory movement of part or all of the body, or as secondary stereotypy, wherein a manipulable object was incorporated into such a repetitive movement.

Six children, four boys and two girls between the ges of six and 14 years, participated as subjects. Descriptive data such as sex, age, and diagnostic information are presented for each subject in Table 1.

TABLE 1

BACKGROUND INFORMATION ON ALL SUBJECTS

Subject	Sex	Age at Time of Study	Diagnosis	Age at Diagnosis	Other Diagnoses	Age of Onset	Score on Rimland Form B2 Checklist		
							Behavior	Speech	Total
J.G.	M	14 yrs. 6 mos.	Autism	4 years	Childhood Psychosis;	2 years	+9	0	+9
S.G.	F	10 yrs. 10 mos.	Infantile Autism	(after 3 years 6 mos.)	Abnormal EEG and Hyperactivity	2 years 6 mos.	+5	-4	+1
D.H.	M	12 yrs. 2 mos.	Severely Autistic	3 years	Retarded	"Noticeable at age 3"	+9	-2	+7
E.M.	F	6 yrs. 6 mos.	Childhood Autism	5 years	Hyperactivity	1 year	+4	+2	+6
J.R.	M	14 yrs. 6 mos.	Retarded with Autism	(after 2 years 6 mos.)	Russell's Dwarf Syndrome	2 years 6 mos.	+3	+2	+5
D.Z.	M	11 yrs. 9 mos.	Autistic Tendencies	2-3 years	-	2 years 6 mos.	+19	+12	+31

Apparatus

Each subject was observed individually in our laboratory experimental room with our display system as described above. The three experimental stimuli were 1) rhythmic asynchronous strobe, 2) rhythmic asynchronous drumbeat, and 3) the simultaneous rhythmic asynchronous presentation of 1 and 2. A pair of xenon strobe lights were positioned behind the appropriate translucent panel(s) so as to diffusely illuminate the panel. Two pairs of strobes were available for the Strobe vs. Strobe and Drumbeat pairing. The strobes in each pair were set at different flicker rates, approximately 3.5 and 5 flashes per second. In this way the pair of strobes behind a single panel would be asynchronous, but the appearance of any one panel would be the same as the other. The rhythmic asynchronous drumbeat was produced on two drums tapped at average frequencies of two and five beats per second, respectively. The drumbeat was recorded on a one-minute TDK Endless cassette loop and presented through the appropriate speaker(s) in the display board. The stimulus case, which signalled to the subject that the panels were active for the Choice phase, consisted of color slides back-projected onto the translucent display panels.

A timing cassette marking three-second intervals of alternating observation and recording intervals was heard by the observer via earphones during all observation periods. The computer recorded number of panel presses throughout the experiment and, in the Choice phase, the chosen stimulus and response time for each presentation of paired stimuli.

Experimental Design

Four factors were experimentally varied in a 2 x 3 x 3 x 2 completely randomized factorial design. Twelve sessions of approximately 24 minutes each were required for each subject in order to present the entire design. Throughout all sessions, an observer recorded the occurrence of each stereotyped behavior using a time-sampling technique.

Each subject was observed under all conditions of the design. Thus the results from each subject could be analyzed separately as successive replications of the experiment.

Independent Variables

The four categories of independent variables were (A) Stimulus Availability (two conditions); (B) Contingency (three conditions); (C) Stimulus Type (three conditions); (D) Object Availability (two conditions).

Stimulus Availability. The first comparison was between the Baseline condition of minimal constant stimulation and the Experimental Stimulus condition of rhythmic asynchronous stimulation presented through the display board. Each day's session was divided into six period lasting four minutes each. Each of the three Experimental Stimulus periods was preceded by its own Baseline period of minimal constant stimulation. This temporal matcing was designed to control for extraneous behavioral variations resulting from day-to-day shifts in activity level, from time of day, or from residual effects of the previous Experimental Stimulus period.

Contingency. The mode of presentation of the rhythmic asynchronous stimulation was experimentally varied between 1) Fixedccc No Choice, 2) Choice, and 3) Matched No Choice conditions. In Fixed No Choice, the experimental stimulus was activated automatically at the beginning of the Experimental Stimulus period and remained on for four minutes. In the Choice condition, the subject activated the experimental stimulus by pressing the panel. Each panel press activated the stimulus for 15 seconds. Subjects could therefore choose not to activate the panels, providing 0 seconds of the experimental stimulus and 4 minutes of minimal constant stimulation, interrupted by successive 10-second presentation of the monochromatic stimulus cues illuminating the side panels, each followed by 15 seconds of minimal constant stimulation. Alternatively, subjects could provide themselves with as much as 4 minutes 15 seconds of virtually constant stimulation. In the third condition, Matched No Choice, the experimental stimulus was again activated automatically (non-contingently), though in a pattern of 15 seconds on, 3 seconds off to more closely duplicate the duration and pattern of stimulation created by the same subject in the previous day's Choice session. The number of 15-second presentations was matched across days, but the individual response time intervals were not; 3-second "off" times were used arbitrarily and consistently for all subjects. As in the Fixed No Choice condition, panel presses during Matched No Choice were irrelevant to stimulus presentation.

Stimulus Type. Three types of rhythmic asynchronous stimulation were presented: 1) visual (Strobe), 2) auditory (Drumbeat), and 3) bimodal (Strobe and Drumbeat). On Fixed No Choice and Matched No Choice days, each stimulus was presented in one of the three Experimental Stimmulus periods, as shown in Figure 1.

During Choice days, however, each type of stimulation was not presented successively. Rather, they were presented in pairs, so that subjects could choose between types of stimulation and their preferences be determined. Whereas each stimulus was presented through the center panel and/or speaker in the Fixed No Choice and Matched No Choice conditions, pairs were presented from the side panels and speakers during Choice days. Each pair as presented in one of the three Experimental Stimulus periods for that day (Figure 1). Color slides were back-projected onto the side panels as cues each time the panels could be activated (i.e., when a choice could be made). Training trials were presented prior to each new Experimental Stimulus period to familiarize the subject with the type of stimulation paired with each panel. The cueing and training procedures will be described more fully in the following section.

Object Availability. All conditions described above initially took place with no manipulable objects provided for secondary stereotypy. All conditions were repeated on subsequent days with a set of seven manipulable objects available. These objects were chosen for their affordance of the secondary stereotyped behaviors previously identified for each subject; i.e., the extent to which they could be used to twirl, tap, dangle, etc.

Figure 2 illustrates the presentation of each condition over the twelve experimental sessions (days). To review. Baseline alternated with Experimental Stimulus condition within each day. This was repeated three times within each day for each of the tree stimulus Types (or stimulus pairs on Choice days). The three Contingency conditions each required a separate session. Thus, three of the four independent variables were presented in a 2 x 3 x 3 design in a core 3-session structure. Days 4-6 replicated this structure, varying the fourth independent variable by making manipulable objects available. Thus the complete 2 x 3 x 3 x 2 design was presented in six sessions. This entire procedure was replicated in Days 7-12, changing only the order of presentation of each stimulus or stimulus pair within each session, and the left-right panel location of each stimulus in Choice, as control measures.

Fixed No Choice
Days 1, 4, 7, 10

(2 minutes - Adjustment to room)
4 minutes - Baseline I
4 minutes - Stimulus I
4 minutes - Baseline II
4 minutes - Stimulus II
4 minutes - Baseline III
4 minutes - Stimulus III

Choice
Days 2, 5, 8, 11

(2 minutes - Adjustment to room)
4 minutes - Baseline I
  (5-? trials - Training for Pair I)
4 minutes - Pair I
4 minutes - Baseline II
  (5-? trials - Training for Pair II)
4 minutes - Pair II
4 minutes - Baseline III
  (5-? trials - Training for Pair III)
4 minutes - Pair III

Matched No Choice
Days 3, 6, 9, 12

(2 minutes - Adjustment to room)
4 minutes - Baseline I
  (0-? minutes - Matched Social Intervention, Stimulus I)
0-8 minutes - Stimulus I
4 minutes - Baseline II
  (0-? minutes - Matched Social Intervention, Stimulus II)
0-8 minutes - Stimulus II
4 minutes - Baseline III
  (0-? minutes - Matched Social Intervention, Stimulus III)
0-8 minutes - Stimulus III

Figure 1. Procedural structure within experimental sessions: Fixed No Choice, Choice, and Matched No Choice.

	Fixed No Choice Sessions	Choice Sessions	Matched No Choice Sessions
Manipulable Objects NOT Available	Day 1 S_1 S_2 S_3	Day 2 S_1S_2 S_2S_3 S_1S_3	Day 3 S_1 S_2 S_3
Manipulable Objects AVAILABLE	Day 4 S_1 S_2 S_3	Day 5 S_1S_2 S_2S_3 S_1S_3	Day 6 S_1 S_2 S_3
Manipulable Objects NOT Available	Day 7 S_3 S_1 S_2	Day 8 S_3S_2 S_3S_1 S_2S_1	Day 9 S_3 S_1 S_2
Manipulable Objects AVAILABLE	Day 10 S_3 S_1 S_2	Day 11 S_3S_2 S_3S_1 S_2S_1	Day 12 S_3 S_1 S_2

Days 4-6 replicate Days 1-3 except for introducing a manipulable object

Days 7-9 replicate Days 1-3 only rearranging order of presentation of stimuli and stimulus pairs

Days 10-12 replicate Days 7-9 except for introducing a manipulable object

Figure 2. Day-by-day structure of experimental sessions 1-12, illustrating the four replications of a core 3-session structure, differing only in 1) order of presentation of stimuli and stimulus pairs as listed within the boxes, and 2) availability of manipulable objects.

Procedure

All sessions took place in the presence of a trained observer, who was seated behind the one-way mirror. Stereotyped behaviors observed during alternate 3-second intervals were recorded on score sheets during the intervening 3-second intervals. This time-sampling technique yielded data on 50% of the total time each subject was exposed to each experimental condition, or, for example, 40 three-second intervals for each four-minute period.

Preference Hierarchies for Stimulus Type: The Instrumental Response. The panel press served as the instrumental response within the Choice condition, activating a 15-second burst of the associated experimental stimulus. Total number of panel presses out of total number of choice opportunities were recorded for each subject. Due to the paired presentation format of experimental stimuli in the Choice condition, preference hierarchies could also be determined for each subject.

The Time-Sampling Observational Record on the Occurrence of Stereotyped Behaviors.

Stereotyped behaviors occurred and were recorded during all phases of the experiment (contingencies for Forms I, II, and III), thus serving as the primary unit of comparison of subjects' response to the experimental manipulators.

As the beginning of each experimental session the subject was seated in front of the display board and instructed by name to stay there. All subjects were familiar with the test room and apparatus from a previous computerized discrimination learning program. Thus the panel press response to an illuminated panel was a familiar, rewarded behavior. As the subject entered the room, however, and during Baseline, the panels were dark. The room was dimly lit and extraneous sounds from outside the room were muffled, providing minimal constant stimulation identical to Baseline. The actual experimental session began following an initial two-minute period during which the subject could become accustomed to the room and the observer could get into position to record.

The experimental session began when a) the observer started the audio timing tape, and began observing and recording in alternating 3-second intervals the subject's stereotyped behaviors, and b) the experimente signalled the computer to begin timing Baseline I and counting any panel presses. Nothing changed for the subject inside the test room; the room remained at minimal constant levels of stimulation.

Fixed No Choice Sessions

On Days 1, 4, 7, and 10 the Baseline I period continued for 4 minutes. Stimulus I (Drumbeat for Days 1 and 4; Strobe for Days 7 and 10) was then automatically activated by the computer and preented through the center speaker and panel. The stimulus continued constantly for 4 minutes, regardless of panel presses or any other behavior of the subject. Baseline periods preceded Experimental Stimulus periods through presentation of the other two stimuli. The session was over at the end of the third Experimental Stimulus period.

Choice Sessions

On Days 2, 5, 8, and 11 the Baseline I period also continued for 4 minutes. Immediately following Baseline, training trials for Stimulus Pair I were presented to familiarize the subject with which panel and color were associated with which stimulus in that pair. Position of each stimulus in a pair was kept constant through that Experimental Stimulus period, but was reversed in its other pairing fro that session. For example, on Day 2, Strobe was presented from the subject's right panel when paired with Drumbeat, but from the left panel when poaired with Strobe and Drumbeat.

Training Trials. Training trials were presented in sets of five. The first two trials were single-panel illuminations in the sequence Left, Right. This color cue remained illuminated for a maximum of 10 seconds. An appropriate panel press within that 10 seconds activated the experimental stimulus for 15 seconds. If no response was made, or if both panels were pressed, the panel darkened immediately and remained so for 15 seconds (i.e., Baseline conditionn of minimal constant stimulation). At the end of 15 seconds, the appropriate panel was color illuminated to cue the second trial.

Both panels were color illuminated to cue the third, fourth, and fifth training trials as they would be in the actual Choice experimental period. An appropriate response to training trial five served as the criterion for beginning the actual test period. A single panel press of either panel would activate the appropriate stimulus for 15 seconds, after which the actual Experimental Stimulus period would begin. If neither, or both, panel(s) were pressed in the 10-second cue interval, Shaping procedures would begin.

Response Shaping. The experimenter entered the test room and knelt behind the subject's chair for the first four trials of the next trainig block. Physical prompts and verbal cues ("Push") were used to elicit the appropriate response. Prompts were faded out as rapidly as possible so as to provide minimal interference. The experimenter left the room during the 15 seconds of stimulus presentation from Trial 4, so that the subject responded independently to Trial 5. An appropriate response to Trial 5 would be followed by the first trial of the actual Experimental Stimulus period, and the observer would begin recording behaviors with the presentation of the first trial. No response to Trial 5, or both panels pressed, would be followed by a second block of Response Shaping trials, the experimenter again leaving the room prior to Trial 5.

A maximum for four sets of Response Shaping trials were given prior to each Experimental Stimulus period. Stereotyped behaviors were not recorded during training trials no Response Shaping trials, nor were panel presses during those trials included in the data.

Experimental Stimulus Period. As in the third through fifth training trial, choice "trials" were presented throughout the four-minute experimental stimulus period. Subjects had from 10 to 16 opportunities to make a choice and activate one of the stimuli in the pair, depending on how rapidly they responded after the next "trial" was cued.

At the end of the Pair I period, Baseline for Pair II began. Procedures were repeated for Pair II and III Training Trials, Response Shaping trials (if needed), and experimental stimulus periods. The session was over following the Pair III Experimental Stimulus period. Since each Stimulus Type was available during two Experimental Stimulus periods per Choice session, it is important to note that any one stimulus could have been activated from 0 seconds to 8 minutes 28 seconds. This has important implications for the structure of the Matched No Choice sessions.

Matched No Choice Sessions

In days 3, 6, 9, and 12, experimental stimuli were again presented separately, each experimental period preceded by its own Baseline condition. Presentation of stimuli was again noncontingent on panel presses, and stimuli were presented from the center speaker and panel. However, the procedure for Matched No Choice sessions varied in three respects from Fixed No Choice sessions.

Each session was matched with that subject's performance in the previous day's Choice session, with respect to 1) the duration that each experimental stimulus was activated, 2) the interrupted pattern of stimulus activation, and 3) the amount of social intervention experienced during the Response Shaping trials.

Duration of Experimental Stimulus Periods. Total time each experimental stimulus was presented in the Matched No Choice session equalled that experienced during the previous day's Choice session, i.e., 15 seconds x the number of times that stimulus had been selected the previous day. If a particular stimulus was not chosen in either of the two pairings of a Choice session, no Baseline or Experimental Stimulus periods could be presented for that stimulus in the Matched No Choice condition the following day.

Pattern of Stimulus Activation. In order to replicate the noncontinuous pattern of stimulus presentation created by the discrete trial format of the Choice session, experimental stimuli were again presented in 15-second bursts, separated by 3-second "off" intervals.

Amount of Social Intervention. Following each Baseline period during Matched No Choice sessions, the experimenter entered the test chamber, returned the subject to the chair if necessary, and knelt behind the chair for an interval equal to the duration of social interaction in Response training trial blocks the previous day, 100 seconds allowed for each block of trials. Occurrence of stereotyped behavior was not recorded during this procedure. An attempt was made to replicate the amount of physical contact and verbalizations required for prompting the previous day.

Matched No Choice sessions were completed when all stimuli selected the previous day had been presented.

Object Availability

Procedures for Days 4-6 and 10-12 were identical to those for Days 1-3 and 7-9, respectively with one exception. Days 1-3 and 7-9 were observed with no manipulable objects available for secondary stereotyped behaviors. During Days 4-6 and 10-12, With Object days, a set of manipulable objects was placed on the desk in front of the display board before the subject entered the test room. These objects were chosen for their usefulness in performing previously identified secondary stereotyped behaviors of each subject, as listed in Table 2. The set of manipulable objects consisted of:

1	5 1/2" gold plastic saucer
3	1 1/2" wooden blocks
1	unsharpened yellow pencil with eraser
1	blue cloth loop, tied at ends
1	9" length of white string
1	gold tassell, 5" long
1	clear plastic Sterling Circle Template (stencil, measuing 6 3/4" x 4" with 22 circles measuring 1/16" to 1 1/2" in diameter

Order of Stimulus Presentation

Days 7-12 replicated all conditions and procedures of Days 1-6, matched days for day, with two exceptions. First, the order in which experimental stimuli or stimulus pairs were presented within each session was changed. Secondly, the right-left positions of each stimulus in a pair were reversed in the Choice sessions.

Scoring Observed Stereotyped Behaviors

Prior to the experimental sessions, an observer was trained in the time-sampling observational technique. Reliability between the observer and the experimenter for all subjects ranged from 85% to 92%. Reliability was determined on the basis of total agreement in each 3-second observational interval.

It was the task of the observer to record the occurrence of individual stereotyped behaviors. Observations for each 3-second observation interval were encoded on the Data Sheet during the next 3-second recording interval, during which the subject's behavior was not observed. In the Choice sessions, the observer was required to note the choice and duration of a particular experimental stimulus across observational intervals.

Results

The Instrumental Response

The six subjects varied markedly in their responses to the Choice situation. The occurrence of the panel press response varied from almost total participation (160 selections out of 162 choice opportunities by subject J. G.) to almost total avoidance (one selection out of 115 choice opportunities by subject S.G.).

Z-score analysis of the differences between two proporitons (Edwards, 1968) was used to determine the statistical significance of differences between choice due to the unequal number of choice opportunities across subjects. Overall, three subjects significantly preferred some sort of elicited environmental stimulus over the minimal constant stimulation following No Response ($\underline{p} < .01$). Two other subjects provided No response more often than any single stimulus, though all three stimuli, in combination, occurred slightly more often than No Response. The sixth subject, as mentioned, steadfastly avoided all stimuli, despite having 184 training trials in which she responded with prompting and exposed 15 seconds each of the associated stimulus (see Table 6).

Subjects also varied on the ordering of their preferences within the various types of rhythmic asynchronous stimuation. Once subjects were present, two subjects decreased their participation in the choice contingency, apparently being more interested in the objects.

The Occurrence of Stereotyped Behavior

In order to examine the effects of the independent variables, a score was obtained from the behavioral data recorded by the observer. Each score consisted of the number of individually-identified streotyped behaviors occurring over three consecutive observational intervals, or a total of nine seconds of time-sampled observation. Each four-minute experimental period yielded 13 such scores which can be regarded as replications under the same experimental conditions.

These behavioral scores reflect the intensity of stereotyped activity in that they preserve information on the number of behaviors occurring simultaneously. The highest number of behaviors recorded in any one interval was four. Scores derived from three-interval blocks could therefore range from 0 to 12.

Table 3 provides the Grand Mean Scores for Primary, Secondary, and Totalled Stereotyped Behaviors observed for each subject across observational sessions.

All scores were subjected to a four-factor Analysis of Variance for the 2 x 3 x 3 x 2, fixed effects design. Separate ANOVAs were performed for each subject, and for primary, secondry, and totalled scores within each subject. In addition, three-way ANOVAs were performed to examine the effects of Factors B, C, and D under Experimental Conditions only; that is, shen the Rhythmic Asynchronous Stimulation was actually being presented.

TABLE 3

MEAN SCORES FOR PRIMARY, SECONDARY AND TOTALLED STEREOTYPED
BEHAVIORS OBSERVED FOR EACH SUBJECT ACROSS
ALL OBSERVATIONAL SESSIONS[1]

Subject	Primary SB	Secondary SB	Totalled SB	Estimated Mean Number of Behaviors Per Interval
JG	1.60	1.37	2.97	.99
SG	.79	1.60	2.39	.80
DH	2.14	.53	2.67	.89
EM	1.32	.50	1.82	.61
JR	2.15	.48	2.63	.88
DZ	1.49	.47	1.95	.65

[1] Scores = the number of stereotyped behaviors observed over three consecutive three-second intervals. Estimated mean number of behaviors per interval = 1/3 grand mean score.

The Effects of Introduction and Alteration of Rhythmic Asynchronous Stimulation: Factors, A, B, and C

The introduction of rhythmic asynchronous stimulation had an effect on the stereotyped behavior (SB) of only one of the six subjects in this investigation. That is, five subjects demonstrated no significant differences in ongoing totalled stereotypy, regardless of the presence or absence of rhythmic asynchronous stimulation. Since variations in stereotypy observed across Factor B (Contingency) conditions, and across Factor C (Stimulus type) conditions, were paralleled by changes in their corresponding Baseline periods, no conclusions can be drawn concerning significant variations in Factors B and C for these five subjects (i.e., any observed variations cannot be attributed with confidence to the effect of the independent variables).

Only one subject exhibited a significant variation in stereotyped behavior (SB) between Baseline and Experimental Stimulus conditions. Behavioral trends were noted in one other subject, and in a third subject for secondary SB only. Absence of significant variance for Factor A for the other three subjects makes it impossible to attribute variations across Factors B or C to the experimental variables themselves. Therefore, the introduction and alteration of rhythmic asynchronous stimulation significantly affected ongoing stereotypy in only one of the six autistic subjects. The two subjects who demonstrated a decrease in totalled SB once rhythmic asynchronous stimulation more often than not when given a choice. The one subject who increased her secondary SB when rhythmic asynchronous stimulation was presented, consistently choose *not to* activate such stimulation when given the opportunity. Of those two subjects who made Choices (and have variations in SB attributable or possibly attributable to the introduction of the Experimental Stimulus), one subject decreased SB during Choice conditions and the other subject tended to increase SB during Choice, particularly over that observed during Matched No Choice.

The Effects of Object Availability

The availability of manipulable objects had a far more dramatic effect on overall stereotypy than did the rhythmic asynchronous experimental stimuli. Five of the six subjects demonstrated a significant variance ($p < .001$) in both primary and secondary stereotyped behaviors across these conditions, with four of these subjects showing significant variation in totalled stereotyped behavior. In five subjects, as expected, there was a significant increase in secondary stereotyped behavior once manipulable objects were available. In the sixth subject, E.M., the relatively high without-object mean score of secondry behaviors (.51) remained essentially unchanged once objects were introduced, since her favorite behavior involved manipulation of clothing. In the other five subjets, there was a concommittent, significant *decrease* in primary stereotyped behaviors once objects were introduced; i.e., secondary behvaiors were replacing primary body movement. This inverse relationship produced an overall increase in totalled stereotyped behavior in the presence of objects in two subject ($p < .001$ for J.G. and S.G.), with trends in this direction for a third, subject D.Z ($F = 3.322$, $p < .069$ overall; $F = 4.646$, $p < .032$ for experimental sessions only). Totalled stereotyped behaviors actually decreased for two other subjects (J.R. and D.H.) once manipulable objects were available.

In five of the six subjects, therefore, expected increases in secondary stereotypy were accompanied by significant drops in the occurrence of primary stereotyped behaviors, indicating that secondary SB was preferred over Primary SB under these conditions. The Absence vs. Presence of Manipulable Objects had an effect on the choice patterns of four of the six subjects, altering 1) the tendency to select or note select some rhythmic asynchronous stimulus (subjects D.h. and J.R., and 2) the preference ranking of individual kinds of rhythmic asynchronous stimulation (subjects J.G. and E.M.).

The response patterns on both the instrumental response and the occurrence of stereotyped behaviors were quite varied across these six autistic subjects. Five of the six subjects clearly demonstrated the capacity (and desire, under certain conditions) to work to produce the rhythmic asynchronous experimental stimulation. However, only one subject demonstrated a significant variation in the occurrence of stereotyped behavior dependent on the introduction of the experimental stimuli.

By far the most marked effect across subjects was the demonstrated preference for engaging in stereotypic object manipulation, rather than ritualistic bodily movements. This effect was observed in five of the six subjects participating in this investigation.

Examination of stimulus preferences, which took into account the self-stimulatory quality of stereotypy itself, again revealed mixed preferences among subjects. Three subjects preferred the internally-generated tactile stimulation of Secondary SB, isolated from the available visual and auditory environmental stimulation. One subject preferred a combination of environmental and internally-generated stimulation, a fifth preferred simple unimodal environmental stimulation, and the sixth preferred a variety of environmental stimuli, either alone or accompanied by stereotypic, possibly self-stimulatory bodily movements.

Discussion and Conclusions

As expected, the six autistic subjects did indeed show a marked tendency to engage in stereotyped behavior (SB) within the experimental setting. It was confirmed that external factors do affect the contingency structure of stereotyped behavior in children with autism, but in an individualized manner. The most relevant external factor in the present study was the Availability of Manipulable Objects, which significantly altered overall rates of stereotypy in five of six subjects. Responses to the presentation of the stimuli Strobe, Drumbeat, and Strobe and Drumbeat varied across subjects, as did their response to the panel press Choice contingency.

The Three Forms of Stereotyped Behavior

A schematization for three Forms of Stereotyped Behavior was proposed above based primarily on apparent contiguity of SB and environmental events. It was stated that both primary SB (repetitious body movements) and secondary SB (stereotypic object manipulation) can occur in apparent isolation (Form I SB) or can occur in accompaniment to certain forms of environmental stimulation (Forms II and III). This was of course the purpose of the present investigation: to explore the parameters of both primary and secondary stereotyped behavior through controlled variation in environmental stimulation and through observation of subsequent SB. The experimental stimuli Strobe and Drumbeat altered the configuration of stimulus input in intensity and rhythmicity over that present in the minimal constant stimulation of Baseline, while the bimodal presentation of these stimuli further increased the complexity of the stimulus array.

Thus the laboratory setting and experimental conditions were designed to allow us to observe all three Form levels of SB in our subjects. While the minimal constant stimulation of Baseline modeled conditions for "spontaneous" (Form I) stereotypy, conditions for "elicited" stereotypy of Forms II and III were modeled by the noncontingent Fixed and Matched No Choice) and contingent (Choice) presentation of the Rhythmic Asynchronous Experimental Stimuli (RAS), respectively.

Interestingly, this manipulation did not have the expected effect, in that the introduction of more intense, complex rhythmic stimuli did not significantly increase rates of ongoing stereotypy. Only one out of six subjects showed any significant variations in Totalled SB between Baseline minimal constant stimulation and Presentation of Rhythmic Asynchronous Stimulation (Factor A in the analysis), and this change was in the direction of decreased SB once the RAS was introduced. Upon examination, it is possible that this failure to observe a clearer difference in frequency of these behaviors may be due in part to a ceiling effect, considering the extremely high rate of SB observed across conditions for all subjects. Subjects averaged from .61 to .99 stereotyped behaviors per three-second observational interval. It is noteworthy that the two subjects who achieved or approached significant variation (E.M. and D.Z., respectively) had the lowest mean number of stereotgyped behaviors per three-second interval (Table 3). The other four subjects, who failed to demonstrate a difference in SB with and without the rhythmic asynchronous stimulation, averaged from .80 to .99 behaviors per interval--almost constant engagement in stereotyped activities. In other words, in order to get an effect, one condition would have had to actively interfere with SB, since rates were so high that enhancement was nearly impossible.

At any rate, five of the six subjects did indeed engage in stereotypy under conditions modelling all three Forms of stereotyped behavior. The sixth subject, S.G., was observed to engage in stereotypy under Form I and II conditions, yet consistently refused to work to create the environmental event (RAS) to which she could, in turn, engage in stereotypy.

All subjects were observed to engage in spontaneous (Form I) stereotypy during Baseline conditions of minimal constant stimulation. Form II ("environmentally-induced") stereotypy was modeled for each subject during both Fixed and Matched No Choice. All subjects maintained a fairly high rate of stereotypy under both conditions, i.e., in the presence of noncontingent RAS. Five of the six subjects were observed to engage in Form III stereotypy, i.e., that occurring in the presence of the rhythmic asynchronous stimulation that they themselves activated.

Observations on Levels of Arousal

The present investigation was intended as a descriptive study of the effect of certain environmental manipulations on autistic stereotyped behavior, not as a test of any of the five theories on the etiology of stereotypy. Observed patterns of stereotypy do not clearly raise issue with, nor clearly refute, current thinking on the role of arousal, learning, or development in the origin and maintenance of stereotypy.

Though it is impossible to specifically determine or quantify individually preferred levels of arousal, observed response patterns of subjects in the present study suggest wide individual variation in what constitutes optimal levels of arousal. Subjects were observed to regulate their behavior to maintain some preferred intensity of overall stimulation. One subject refused to activate available external stimuli, though still creating some internal feedback stimulation through both primary and secondary stereotypy. This behavioral pattern could be interpreted as an attempt to minimize arousal from incoming stimulation. At the other extreme, another subject worked diligently to provide himself with as much stimulation as possible, suggesting that he was attempting to maximize his own level of arousal.

The remaining four subjects neither refused, nor constantly worked, to provide themselves with stimulus input. Rather, their behavior often varied across conditions so as to, in effect decrease one form of stimulus input once another (apparently preferred) source of stimulation was available. Such variability in internal and external stimulus activation might be interpreted as an attempt to mediate the intensity of internal arousal and therefore suggests individualized criteria for what constitutes optimal levels of arousal.

Stereotyped Behavior Relating to Object Availability

By far the most interesting effect of the experimental contingencies was subjects' responses to the Availability of Manipulable Objects. For five of the six subjects, the introduction of manipulable objects and the opportunity for secondary SB significantly reduced the occurrence of primary SB. In four of these five subjects, secondary SB effectively replaced primary SB as the preferred activity.

The fact that repetitive object manipulation tended to replace stereotypic body movements is quite encouraging. As discussed in the Introduction, Secondary SB can be described as a developmentally more advanced behavior. Piaget (1963) drew a distinction between body-centered and object-focussed repetitive behaviors as they normally occur in infant development. Repetitive movement or attention to parts of the body are characteristic of the sensorimotor phase, which occurs from one to four months of age. The infant's attention later shifts to external objects, and the earlier body-centered activities are gradually replaced by repetitive manipulation of objects in the environment. This latter shift normally takes place from about four to nine months of age, in what Piaget referred to as a secondary reaction phase. Smith and Smith (1962) also argued for the developmental primacy of body movements, which could be considered part of 1) postural adjustment in relation to gravity, 2) ballistic movement in freespace, or 3) movement in hard space, i.e., with spatial boundaries. Secondary SB would be more closely equivalent to the last class of movements developed: movement in relation to hard space. It should be noted that Piaget regarded ciruclar reactions as most important developmentally, in that they would provide the basis for higher-order cognitive structure.

It is interesting that Secondary stereotyped behaviors are themselves usually less rigid than Primary SB because of the need to accommodate the physical constraints of each new object that still affords the Secondary SB. It can be argued, then, that the preference for Secondary SB is a positive finding developmentally, in that these subjects were advancing from a less adaptive form of the behavior. Furthermore, participation in the learned, non-stereotyped manipulative Panel Press can be seen as even more advanced developmentally, since it required learning a new behavior and set of contingencies. It may be argued that the most developmentally appropriate behavior within the experimental constraints of this study was the acquisition and participation in the new manipulative behavior without subsequent SB, where the new contingencies in effect could substitute for the old stereotyped activities. Such a behavioral shift would demonstrate even greater flexibility on the part of the autistic child. This did indeed happen for two subjects--the two for whom Secondary SB did not replace Primary SB. Three of the other subjects preferred the feedback from their own Secondry SB to the stimulation provided by a panel press, while the fourth subject preferred to activate the external stimuli and continue his Secondary SB. Subject D.Z. preferred to create each of the experimental stimuli and attend to each unaccompanied by feedback from his own SB, although his second choice combined each stimulus with Primary SB. Subject E.M. most clearly demonstrated the substitution of the panel press contingency for SB, in that she provided herself with each of the unimodal stimuli, unaccompanied by any stereotyped behavior.

Conclusions and Directions for Future Research

The present experimental design allowed us to observe three forms of stereotyped behavior in children with the disability of autism. Stereotyped behavior was observed to accompany minimal constant stimulation, arbitrary presentation of rhythmic asynchronous environmental stimulation, and (in five of six subjects) this same environmental stimulation now activated by the subject himself. Responses varied considerably across subjects, both inn their willingness to press the panel to activate the external stimuli, and in their patterns of stereotyped behaviors across all experimental conditions. It was argued that the most marked effect, replacement of Primary SB with Secondary stereotypic object manipulation, was a developmentally appropriate behavioral trend. Two other subjects apparently replaced Primary stereotypy with the learned panel-press behavior to elicit an environmental stimulsu; this was also seen as a more advanced response to the experimental conditions. There was also evidence that these autistic subjects were indeed using their own stereotyped behavior to regulate internal levels of arousal, though it would appear that optimum arousal levels varied widely across individuals.

An Automated Research and Training System
for Child-Clinical Populations

When the literature concerned with training various populations of handicapped children is reviewed, a practical problem becomes evident. Most of the procedures designed to accelerate learning, for example, in autistic, schizophrenic, and retarded children require implementation through a one-to-one trainer-child ratio ((1,2). Very few research studies or training programs have focused on the development of habilitative or remedial interventions that are implemented with marketable software programs or automated apparatus. This is particularly true in the important area of language training, in which most of the research has been concerned with the acceleration of imitative speech with individualized shaping procedures (3). Most educational and treatment facilities lack the funds for a sufficient number of behavior modification teachers, primarily because of the low child-to-teacher ratios required by existing remedial procedures. Furthermore, such facilities do not have the resources for adequate in-service staff training. Automated equipment and procedures that would permit training of psychotic and retarded children by minimally trained personnel would therefore be highly desirable.

Additionally, it must be noted that a substantial number of children make little progress with the costly one-to-one training procedures that are currently in use. For example, many children either fail to learn to vocalize in imitation training, or the vocalizations do not become functional. Often, failure to acquire a discrimination or to achieve a learning set can be attributed to the subject responding exclusively to a particular trainer. In this regard, subjects have been observed to perform for some trainers and not others, a problem that consumes time in identifying factors responsible for stimulus control. Moreover, it has been suggested that autistic and schizophrenic children respond more effectively in non-personal than in personal contexts (4). Further, a pragmatic consideration in favor of automated procedures is that the training necessary [illegible] low-functioning children is exceedingly repetitious and monotonous. This frequently results in a serious degree of trainer variability and error during extended sessions when manual procedures are used. Finally, the recent burgeoning of computer-based teaching machines lends itself to optimization of the learning environment by permitting self-pacing, sequentially ordered tasks, small increments in task difficulty, and immediate reinforcement.

These considerations, particularly the potential savings in personnel time, could be expected to justify substantial initial costs in equipment development. In fact, however, there are so few systematic evaluations of the efficacy of teaching machines with child-clinical populations that it would be premature to generalize about their value. Although one study showed that a teaching machine alone was not as effective as a trained teacher, this study also showed that a machine used in conjunction with a teacher was an effective combination (5). Further, Russo et al. concluded that the factors contributing to the inferiority of the machine alone required elucidation. Establishing what these factors are, whether they are generally operative, and whether they can be obviated, are issues the present writers hope to resolve over the next few years.

The purpose of this article is to describe automated procedures and equipment that are being used in our studies of retarded and psychotic children. The procedures and equipment can be used in a wide variety of training applications; e.g., those requiring auditory, visual, and bimodal stimulus processing in such tasks as match-to-sample, sign tracking or autoshaping, and the acquisition of number and language concepts. Training procedures which require precise timing in stimulus presentation and termination--e.g., the errorless learning procedures, stimulus fading and stimulus delay--can be implemented with the system.

Design Considerations

The system is based on an Apple IIe microprocessor computer. The microprocessor has a 64K memory and uses a floppy disk system consisting of two Apple six-inch disk drives for storage of the operating software and data collected during the trials. Programming and entry of operating instructions are done by the Apple keyboard. Response data and program listings can be printed on any standard printer. The disk-based operating system, produced by Apple Computer Incorporated, provides access to an assembly language, and the option of the Applesoft or Integer version of BASIC. In our system currently, all software is implemented using the BASIC interpreter. Although assembly language programming could be used to control the real-time operation of a system such as this, the slower BASIC interpreter provides sufficient accuracy and allows programming by a wider group of investigators. As will be seen below in the discussion of the stimulus/reward subsystem, there are a large number of possible configurations of operations. Furthermore, the use of the BASIC interpreter permits easy modifications of the operational software, thus allowing tailoring of programs to individual subjects or users. Programs can also be compiled using a BASIC compiler to increase the speed of the programs.[1]

The stimulus/response system consists of two 6" by 6" (16 cm by 16 cm) transparent plexiglass panels, mounted horizontally on a aluminum board, through which are projected images from two AMDEC 13-inch color monitors. The panels are spaced 18" apart. Each of the panels is constructed so that a small amount of pressure anywhere on its surface actuates a micro-switch. Additionally, each panel is associated with a speaker that may be operated by a balance control to provide simple tones, music, or spoken words. The computer also controls a DSI Model 310 reward dispenser that drops food reinforcers into a tray below the center panel.

The game control registers on the Apple II can be used to monitor the subject's response by indicating to the computer that one or more of the panel switches has been closed. When a subject presses a panel, the corresponding memory location in the game control register is set to one. By examining the register, the computer can moniter the frequency and location of the panel that has been pressed. The display on the color monitors can be made to present an infinite number of stimuli using the Apple IIe's high resolution or low resolution graphic modes. The stimuli can consist of words, numbers, colors, shapes or any combination of these. Timed loops are used to measure subject's response latencies. These loops can be written into the controlling programs using the FOR-NEXT command or the GOTO command. Such loops could be written in any place in the program that the experimenter would desire allowing a versatile timing system for an infinite variety of uses.

Each of the devices in the system can be operated independently by BASIC programs. With the devices under computer control, each can be operated at any time or in any manner that the investigator requires. The only limitations are mechanical restrictions such as the time required to present the stimulus on the monitors in the high resolution graphics mode, or the time required to dispense rewards to the subject.

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[1] Microsoft Applesoft Compiler by Microsoft Corporation.

A Discrimination Learning Sequence

In order to illustrate the versatility of this system, one of the programs currently being used will be described. It must be emphasized that although a simpler, less expensive hardwired system using slide projectors could have been constructed to run the illustrated sequence, a hardwired system would be limited to this sequence and would not allow other useful modes of operation. In addition, slide projectors have the extreme disadvantage of frequent mechanical failure.

In the learning sequence, the subject is presented with two images projected on the color monitors, one which is "correct" and one which is "incorrect." A predetermined trial interval (TI) is set during which the subject can respond by pressing the panel on which the slide of his/her choice is projected. When the subject responds, or in the case of no response, when the TI expires, the display is terminated. If the choice is "correct," the subject may or may not be rewarded as dictated by the experimental procedure being implemented. After the display is terminated, an inter-trial interval (ITI) is begun. During the ITI, the results of the previous trial are saved and the color monitors "draw" the next display. The panels are monitored to determine the number of ITI panel presses. During the first phase of the ITI, these presses are merely counted. However, any panel press during the last five seconds of the ITI restarts the timer so that repetitive responding during this interval effectively postpones subsequent display presentation indefinitely. This programmed "time-out" (TO) from the opportunity to work for reward is to eliminate indiscriminate responses which otherwise might be maintained by adventitious reinforcement through presentation of the display. In the current application, a five-second TO was considered sufficient to eliminate indiscriminate panel presses. However, all temporal parameters--e.g., the IT, ITI, and TO--can be set and flexibly modified by the investigator as he wishes.

In this example each test level of the discrimination task consists of 10 trials, i.e., 10 presentations of a pair of stimuli. If the subject does not make a choice during the TI, an option is to have the same display pair re-presented until a response is made. Incorrect and correct choices are counted and used to determine the testing sequence. If at any time during a given test the subject makes a total of three errors, that test is terminated, the displays are returned to the last level at which the subject was successful, and a new test is started. If the subject reaches the seventh trial with no errors, the eighth with no more than one error, or the tenth trial with no more than two errors, he is advanced to the next, more difficult, test level. This sequence continues until the investigator terminates the run (e.g., because stability or failure criteria have been reached) or until the subject progresses through the entire set of available tests.

The visual display presentation sequence and the reward protocol are entered by the experimenter into the system through a set of data tables. These tables direct the execution of the controlling programs with respect to choice of appropriate subroutines. Each subroutine "draws" the display that is to be presented by the left and right color monitor and indicates which display is "correct." The subroutine also contains the reward controls. These controls correspond to one of the 10 trials specified. This method of control allows precise determination of the display presentation sequence and specification of as many as 10 potentially reinforced responses for each test level. With the flexibility provided by the system, it is a simple matter to vary the schedule of reinforcement. For example, the children might be exposed to progressively leaner schedules of reinforcement in a manner that is sensitive to the individual child's rate of errors and/or nonresponding.

Auditory Cues that Can Be Used in Visual Discriminations

There are currently available software packages (some of which require additional hardware) which will synthesize voices.[2] These packages will either take a prerecorded voice and digitize it or synthesize a voice from text. The inflections and pronunciations can be changed to make the design of software very versatile. These methods can be used to provide auditory cues in testing or experimental task sequences.

The audio-display currently used consists of three speakers, one located above each of the three visual display panels. The spoken word may be presented over any of the three speakers, depending upon the nature of the task. For example, it may be presented as a prompt on the speaker corresponding to the slide it designates and thereby provide a position cue. The auditory prompt may then be gradually faded to the center speaker and thereby require attention to the auditory cues' specific acoustic properties (e.g., "spoon" as distinguished from "shoe"). Any combination of the three speakers can be used. Three gain-programmable amplifiers are used with 256 settings, each of which can be selected by the program; this permits the fading up or down of any or all speakers over trials. The computer can be programmed to have the fading of auditory and visual cues progress in a manner that is sensitive to the accuracy of the child's response. Eight peripheral input/output slots in the Apple IIe permit the addition of other computer controlled equipment to the auditory system.

In conclusion, many practical and theoretical problems remain to be studied regarding the implementation and utility of systems of the type described. Among these are questions of display size and configuration, temporal interval selection for various tasks, and improved procedures for task-error reduction. Also, the presence or absence of personnel in the room with the child (i.e., remote operation), the use of social reinforcers, prompts and punishers dispensed by the auditory system (i.e., praise, urging, admonishing, etc.), and the use of self-pacing techniques all remain to be more fully evaluated.

We expect to complete a series of studies using the system described within the next year. Considering the steadily diminishing costs of computer equipment, we believe that the future may lie with general purpose systems and software-controlled experimental procedure rather than with hardwired equipment. The system presented here has some of the features and corresponding advantages of the type of system that we anticipate will be increasingly utilized with learning-disabled populations in the future.

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[2] The "Voice" package by MUSE Software Company, 347 W. Charles Street, Baltimore, Maryland 21201 or Echo II Speech Synthesizer by Street Electronics Corporation, 1140 Mark Avenue, Carpenteria, California 93103.

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